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Evaluation of the Impacts of Turtle Excluder Devices (TEDs) on Shrimp Catch Rates in Coastal Waters of the United States Along the Gulf of Mexico and Atlantic, September 1989 through August 1990

BY

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EXECUTIVE SUMMARY

Trained National Marine Fisheries Service observers collected information on catch rates of shrimp and finfish aboard commercial shrimp vessels. Data from March 1988 through July 1989 comparing TED-equipped nets (Georgia TEDs with and without accelerator funnels) and standard shrimp nets were reported in May 1990 (Phase 1). Data from September 1989 through August 1990 comparing TED-equipped nets (Super Shooter TEDs and Georgia TEDs, both with accelerator funnels) and standard shrimp nets are presented in this report (Phase 2). All subsequent statements refer to the latter time period of September 1989 through August 1990, unless specific reference is made to Phase 1. A comprehensive analysis of the combined data sets will be completed in the future. These reports represent partial fulfillment of the Office of Management and Budget (OMB) and House Appropriations Committee requirements with respect to TEDs and their economic impact on the shrimp fishery.

Fishing areas, times and length of tows were controlled by the vessel captain. The catch rates of the vessels participating in the program were not significantly different (P=0.65 for Phase 1 and P=0.77 for Phase 2) from the catch rates of commercial shrimp fleets fishing in the same area. This indicates that our evaluations of TEDs were conducted under conditions similar to those encountered by the commercial fleet. A comprehensive economic analysis of commercial utilization of TEDs will be completed by Texas A&M University.

Variation in the performance of standard and TED-equipped nets with respect to types and frequency of problem tows was more similar within Phases than between Phases. During Phase 1 the frequency of tows without problems was greater than that in Phase 2. A problem tow was defined as a tow in which some complication was encountered, such as trawl doors flipping, occurrence of large tears in the net, twisting of cables, etc. During Phase 2 in the Gulf of Mexico, no problems occurred during 83%, 84% and 85% of the tows for nets equipped with a Georgia TED with funnel, Super Shooter TED with funnel or standard nets, respectively. In the Atlantic the values were 95%, 86% and 92% for the same gear types. Problems were independent of net type for the Gulf of Mexico (Chi-Square, $P > 0.25$). However, in the Atlantic, problems were dependent on net type (Chi-Square, $P < 0.005$).

Differences in shrimp CPUEs between standard and TED-equipped nets (excluding tows with problems clearly unrelated to the presence of TEDs; for example, failure to tie the cod end bag prior to towing) were compared using multivariate paired t-tests. A mean loss in shrimp CPUE of 0.07 ± 0.2361 lb/hr (0.7%) was experienced by TED-equipped nets (Georgia and Super Shooter TEDs combined). This was not statistically significant (try net catch excluded). Analysis of the Georgia and Super Shooter TEDs separately also showed no significant difference in shrimp CPUE between standard and TED-equipped nets. Mean shrimp CPUE was 6.93 lb/hr in the standard net and 6.98 lb/hr in the paired Georgia TED-equipped net for a gain of 0.05 lb/hr. Mean shrimp

CPUE was 11.36 lb/hr in the standard net and 11.20 lb/hr in the paired Super Shooter TED-equipped net for a loss of 0.16 lb/hr.

Mean seasonal differences in shrimp CPUEs ranged from a loss of 0.16 lb/hr to a gain of 0.38 lb/hr for TED-equipped nets (Georgia and Super Shooter TEDs combined). CPUEs were significantly different only during winter.

There was no significant difference in mean fish CPUE for standard and TED-equipped nets combined or for Georgia and Super Shooter TEDs analyzed separately. CPUEs for finfish were 209.9 and 199.5 lb/hr for standard and TED nets (Georgia and Super Shooter combined), respectively, with a mean difference of 10.4 lb/hr. Fish CPUEs were lower in winter and spring than in summer and fall.

A total of 30 turtles were captured during Phase 2 of the observer program, of which 28 were taken along the Atlantic coast and 2 in the Gulf of Mexico. Two Ridley and two loggerhead turtles were landed unconscious. All but one loggerhead were released alive. CPUEs of turtles during Phase 2 of the study in the Atlantic for standard and TED-equipped nets were 0.0334 and 0.0014 turtles/net hr, respectively. In the Gulf of Mexico, the CPUE for standard and TED-equipped nets was 0.0022 and 0.0002 turtles/net hr, respectively.

Yield was modelled to determine the possible impact of various levels of shrimp loss on production. The model showed that a decrease of 2% in fishing mortality rate resulted in no detectable change in the yield of the major shrimp fisheries in the Gulf of Mexico during Phase 2 of the study. Since the actual decrease found in our study was less than 2%, we conclude that there was no detectable loss of shrimp in the Gulf of Mexico as a result of using properly tuned Georgia and Super Shooter TEDs.

Slight decreases in yield would be observed in some shrimp fisheries if loss rates from TED's were in the 10-20% range. With the 10% loss rate we observed from TED's during Phase 1 of the study we calculated a loss only from the pink shrimp fishery of 2-4%. No decreases in yield were observed in either the white or brown shrimp fisheries.

Evaluation of the Impacts of Turtle Excluder Devices (TEDs) on Shrimp Catch Rates in Coastal Waters of the United States Along the Gulf of Mexico and Atlantic, September 1989 through August 1990

Prepared by

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INTRODUCTION

The National Marine Fisheries Service (NMFS) promulgated regulations which required the use of Turtle Excluder Devices (TEDs) on offshore shrimp vessels beginning in June 1987 (Federal Register, 1987), depending upon vessel size, geographic location, and fishing area. Due to a series of judicial, Congressional and administrative actions, TED regulations were not fully implemented region-wide until May 1, 1990.

In 1988 both the Office of Management and Budget (OMB) and the House Appropriations Committee mandated certain studies and reports relating to TED use and testing and evaluating the impacts of TED use on fishermen and sea turtles. The OMB required a study on the efficiency of TEDs in excluding turtles and the House Appropriations Committee required a study of the

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full economic impact of TEDs. This report represents partial fulfillment of these requirements. NMFS, in cooperation with the shrimp industry, initiated a TED Evaluation Program on March 5, 1988. The overall goal of this program was to determine the impacts of the utilization of certified TEDs on shrimp catch rates of commercial trawlers operating on the U.S. Atlantic and Gulf of Mexico coasts. Funding was provided by NMFS, the Marine Fisheries Initiative program (MARFIN), and the Gulf and South Atlantic Fisheries Development Foundation.

Field work for Phase 2 was completed in August 1990. We are reporting observations from September 1989 through August 1990. An earlier report (Renaud _et al_. 1990) covers March 1988-July 1989. All statements in this report refer to the period of September 1989 through August 1990, unless specific reference is made to the earlier report, Phase 1. A comprehensive analysis of the combined data sets will be completed in the future. The program compared shrimp catch rates of TED-equipped trawls with those of standard trawls without TEDs in selected shrimp fishing areas of the southeast region. For this purpose, trained observers were placed on shrimp vessels operating off the coasts of Texas, Louisiana, Mississippi, Alabama, Florida (Gulf and Atlantic), Georgia and North Carolina. Results of this study will be used by Texas A&M University[3] in a comprehensive

[3]Griffin, W. L. and O. Chris. 1991. Evaluation of the economic impact of the turtle excluder device (TED) on the shrimp industry in the Gulf of Mexico. Final Report to be submitted to MARFIN.

economic analysis of the impact of TEDs on the shrimp industry.

Specific objectives of the TED evaluation program were to:

1) Compare catch rates of shrimp from TED-equipped trawls and from standard trawls without TEDs in representative shrimp fishing areas of the Gulf and Atlantic coasts of the U.S. by season,

2) Provide data, results and analytical methods utilized in the study to the NMFS Economics Analysis Branch for use in an economic evaluation of impacts of TEDs.

MATERIALS AND METHODS

Rationale for Testing

During Phase 2 of the study we concentrated data collection efforts on filling in data gaps present at the end of Phase 1. Phase 2 testing focused on the Georgia TED with a funnel and a new TED, the Super Shooter with a funnel, in both the Atlantic and Gulf of Mexico because these devices appeared to show the most promise in terms of shrimp retention and turtle exclusion.

Recruitment of Vessels

Vessels were recruited through the assistance of NMFS port agents, NOAA Sea Grant Marine Advisory Agents, regional shrimp associations and industry contacts. Participation in the study by shrimpers was voluntary. Vessels and crews were neither government leased nor chartered. All participating vessels had appropriate federal authorization to use TEDs in only one-half the trawls when a NMFS observer was on board.

Positioning of Net Types

Experimental design assigned TED-equipped nets and standard nets to opposite sides of the vessel. Nets would be reversed on subsequent trips aboard the same vessel to reduce the affect of the try net on the trailing net; however, this was not always possible.

The try net is a small otter trawl, usually about 10 ft in headrope length, which is towed from a either the port or starboard inboard position simultaneously with the large commercial trawls. The try net is retrieved frequently, generally every 15 to 30 minutes, and the contents provide the shrimper with an indication of what is being caught in the large nets. This information is used by the shrimper in developing his fishing strategy.

Positioning of try nets was not directed by NMFS. Consequently, the number of times the try net would be positioned in front of a standard or a TED-equipped net was not randomly determined. During most of Phase 2, data were collected on catch in the try net. When this was possible, only shrimp catch and tow time were recorded. No fish data were obtained from try nets.

Identification of Study Sites

Observers were placed on shrimp vessels in each of the four major Gulf of Mexico offshore fishing areas: Louisiana, Texas, south Florida, and Alabama-Mississippi. Higher levels of observer effort were allocated for areas which historically had higher shrimp production. Of 310 planned observer days, 75 were scheduled for Louisiana, 75 for Texas, 50 each for east and west Florida, and 60 for North Carolina. Observer days were targeted for the peak regional shrimping seasons in each area, although this schedule was not always implemented due to constraints of voluntary participation by the shrimp industry.

The study depended on shrimpers volunteering to let NMFS personnel collect data on board their vessels. Due to limited response by shrimpers, data came from virtually any vessel whose owner or captain would allow us aboard. Since one of the principal objectives of this study was to evaluate the effect of the use of TEDs on commercial shrimping, the shrimpers decided where and when to fish and which certified TED to use. Our only stipulations were that the shrimper had to use federally approved TEDs, allow gear specialists to properly tune the TEDs, and keep catches from each net separated to facilitate data collection on deck. Therefore, the conditions under which the data were collected were representative of commercial fishing conditions.

Observer Training

All observers were required to have at least a bachelors degree in science and some college course work in biology. They received inhouse training in the form of reviews on: 1) TED research, 2) TED regulations, 3) trawl and TED configurations, 4) modifications to trawling gear that can affect the fishing configuration and shrimp catchability of trawls (published material also provided for reference), 5) field procedures for the TED study, 6) diagnostic keys for identification of sea turtles, shrimp and fish 7) detailed instructions for filling out all data sheets, 8) how to avoid the common errors made on data sheets, and 9) guidelines for summarizing data into trip reports and trip summaries for outside circulation. Approximately 12 hours of video tapes were utilized to familiarize observers with sea turtle biology, shrimp trawling activities, terminology of trawling gear, effects of gear alterations on shrimp catchability of trawls, a variety of TEDs, installation procedures for TEDs and the performance of TEDs underwater.

Observers also received two to three days of intensive training aboard shrimp vessels. This reemphasized all procedures necessary to collect data and fill out data sheets properly. A review of the identification of shrimp and fish species was also made at this time. After their training was completed, observers were dispatched from the NMFS Galveston Laboratory to commercial shrimping vessels working off the coasts of North Carolina, Florida, Alabama, Mississippi, Louisiana, and Texas.

Gear Tuning and Control Tows

The fishing efficiency of all nets used in this study was standardized by NMFS or Texas A&M Sea Grant gear specialists during a participating vessel's initial trip. Prior to installation of TEDs, control tows were made using standard nets adjusted to catch approximately equal amounts of shrimp. Vessel captains were instructed by gear specialists on the proper installation of TEDs. Once TEDs were installed, the gear specialist made necessary modifications to the rigging for the proper operation of the TED, based upon his experience and observation of similar catch rates of shrimp between standard and TED-equipped nets. This procedure was usually accomplished in 2-3 days. The captain was responsible for gear tuning after the departure of the gear tuner. Variation in the tuning ability of captains likely contributed to the variation seen in the TED data, however, to an unknown degree.

Data Collection

Every effort was made to minimize the influence of observers on normal fishing activities. The primary requirement was that catches from each net be kept separated so the total weight of shrimp from each net could be recorded. If necessary, the back deck of the vessel was partitioned with wooden beams to prevent the catches from mixing. A sample of 50 to 70 pounds was shovelled from the contents of each trawl into standard sized plastic shrimp baskets (70 lb capacity). Shrimp and fish were separated from each sample.

Shrimp. The total weight (to the nearest lb) of brown, pink, and white shrimp (Penaeus sp.) combined was recorded for each net for each tow. Separate weights were recorded for each additional commercial shrimp species (eg. Trachypenaeus, Xiphopenaeus, etc). In order for total weights to be standardized, the observer recorded catch as heads on or heads off.

For each net the number of shrimp (heads on) in a subsample of approximately 5 lb from the basket was recorded. Observers were instructed in selecting a representative group of shrimp that was not biased according to shrimp size. In those cases in which the shrimper discarded small shrimp, procedures were modified to include only the size range of shrimp retained by the shrimpers.

Fish. The most abundant finfish species was inferred for each net by casual observation. A group weight was recorded for the fish sorted from the basket sample taken from each net. For each net, a combined weight was recorded of all fish too large to fit into the basket. Since the total weight of shrimp was also recorded for each net, the total weight of fish per net could be estimated assuming direct proportion:

$$F_T = \{ (F_S / S_S) \times S_T \} + F_L$$

where,

F_T = estimated total fish weight,

F_S = sample fish weight,

S_S = sample shrimp weight,

S_T = total shrimp weight,

F_L = combined weight of fish too large to fit in basket.

A detailed description of fish catches and their selective exclusion by TED's vs standard trawls is presented in Gitschlag et al.[4]

Commercial Shrimp Catch. Catch per unit effort (CPUE) in lbs/24 hr fishing day, heads off, from NMFS port agent interviews of the shrimp fishery were compared with CPUE data from our observer trips. These comparisons were used to determine the similarity between this study's CPUEs and those reported by the commercial fleet from the same areas and times.

Sea Turtles. For each turtle caught, the date, location, depth of capture, type of net (TED-equipped, standard or try net), species, length (straight and curved), width (straight and

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[4]A comparison of fish bycatch in standard and TED-equipped nets. Manuscript in preparation.

curved), weight (if possible), and condition (conscious, unconscious, fresh dead, dead but not fresh) were recorded. All turtle sightings were also noted. Dead turtles were 1) marked with spray paint, flipper-tagged and returned to the sea for possible return through the Sea Turtle Stranding and Salvage Network (STSSN) or 2) returned to the laboratory for autopsy. Living turtles were flipper-tagged and released. A CPUE was calculated separately for turtles for the Gulf of Mexico and the Atlantic. Fishing effort (E') was standardized to 100 ft headrope (see Henwood & Stuntz 1987) per tow using the formula,

$$E' = E \times 100/H$$

where E = tow time in minutes
H = sum of the headrope length in feet for a tow
E' = standardized effort

Turtle mean CPUE (R) and its 95% confidence interval (C.I.) were calculated according to Snedecor and Cochran (1967) for ratio estimates using the formula,

$$R = \Sigma T / \Sigma E'$$

where T = turtle captures
E' = standardized effort

$$\text{estimated standard error of } R = \frac{1}{\bar{E}'} \frac{\Sigma(T-RE')^2}{n(n-1)}$$

where n = sample size
$\bar{E}'$ = mean of the standardized effort

Confidence intervals are approximate and based on the assumption that the data follow a normal distribution. We recognize that the data are not normally distributed and appropriate analyses are being developed.

Gear Performance. Each net was characterized by an operation code based on its performance in the water (Appendix I, Table 1). A net towed without incident was coded 'Z'. Other codes were used to describe problems encountered, such as tangling of trawl doors, gear fouling, twisted cables, bag choking, etc. Two codes were occasionally required to describe trawl performance.

Data collected from tows with non-TED related problems were not included in the analyses. These include such things as the cod end of the bag coming untied, gear not fishing properly due to insufficient weight on the lead line, torn nets, broken cables, etc. (Appendix II Table 5). If it was apparent that the TED did cause a problem, then the data were used in the analyses.

Seasons. For analytical purposes seasons were defined as winter (DEC-FEB), spring (MAR-MAY), summer (JUN-AUG) and fall (SEP-NOV).

Statistical Analyses

Multivariate Analyses. Multivariate paired t-tests were performed on paired data to test the null hypothesis of equal catch per unit effort (CPUE, lb/hr) for shrimp and finfish simultaneously for both the standard and TED-equipped trawls. Data were paired by tow. This test is discussed in detail by Morrison (1976). The null hypothesis was:

$$H_o = \begin{pmatrix} \mu_{\text{diff shrimp}} & & 0 \\ & = & \\ \mu_{\text{diff fish}} & & 0 \end{pmatrix}$$

Univariate adjusted paired t-tests were performed whenever the above null hypothesis was rejected. Also, the confidence intervals on each of the parameters (stated in the above null hypothesis) were constructed.

<u>Additional Analyses.</u> Other statistical analyses of the data included frequency distributions, correlations, linear regressions, t-tests and paired t-tests, mean, standard deviation, confidence intervals and other descriptive statistics (Sokal and Rohlf, 1981).

<u>Biological Models.</u> Deterministic population models were produced for all three shrimp species by linking a Ricker-type yield per recruit model to recruitment estimates that were independent of parent stock (Ricker 1975, Nichols 1984, Nance and Nichols 1988). Recruitment level was set at the geometric mean for the 1960-1988 period. Averages of estimates for 1986-1989 fishing mortality (F) derived from virtual population analysis were used as the baseline for current conditions. Yield estimates were made for all three species for a range of "F-multiplier" values ranging from 0-2 by 0.002 increments. Tables of these yield estimates were used to determine effects of TED-equipped nets on the shrimp yield in the Gulf of Mexico. This was possible because yield estimates (Y_t) are a direct result of fishing mortality rates (Royce, 1972). The yield model was:

$$Y_t = F_t\ N_t\ W_t\ dt$$

where,

N_t is the number of animals (R) in a cohort subject to fishing (F) and natural (M) mortality at a given time (t), the formula is:

$$N_t = Re^{-(F + M)(t-t_c)}$$

F_t is the fishing mortality at a given time

W_t is the average weight of an individual at time t, estimated from growth equations.

Fishing mortality rate (F) is the product of two separate variables; i.e., a catchability coefficient (q) and directed nominal fishing effort (f).

$$F = q\ f$$

TED-equipped nets influence fishing mortality (F) by affecting shrimp catchability (q) and not fishing effort (f). Any percentage change in shrimp catchability caused by TED-equipped nets is assumed to be directly reflected by an equal percentage change in fishing mortality. This is based on an assumption of direct proportionality between change in CPUE and change in q. Thus, any change in CPUE as a result of TED use is translated into a proportional change in q.

RESULTS

Descriptive Data Summary

Paired Data. For each tow, data were averaged from all TED-equipped nets and standard nets, respectively, to provide one TED-standard data pair per tow. Usually the average catch of two TED-equipped and two standard nets were paired for each tow. However if one of the nets had an operation code (Appendix II Table 5) that excluded it from the analysis, then just the remaining net would be paired up with the other two. There is the possibility that no comparison could be made for a tow if both nets of a given gear type were disqualified by their operation codes. Figures 1 and 2 show the frequencies of TED-standard data pairs with usable operational codes by geographic area and season.

Data from vessels which kept their nets properly tuned and separated the catches of standard and TED-equipped nets were included in the analyses. Data collected from one vessel testing TEDs in the northern Gulf of Mexico was not included because of **improper** rigging of the nets which was not determined until completion of the trip. The hummerline was too short which probably caused shrimp loss in one or more of the four nets being towed. This vessel is presently rigged with Super Shooter TEDs that are working to the captains satisfaction. In the Gulf of Mexico, information for 123 data pairs was collected from tows using Georgia TEDs equipped with accelerator funnels, and 50 pairs from the Super Shooter TEDs with funnels (Appendix II Fig.

1). There were 65 data pairs in the Atlantic for Georgia TEDs with accelerator funnels and 187 for Super Shooter TEDs with funnels.

Try Net Data. All shrimp vessels normally fish with a try net in front of one of their nets. In this volunteer study the positioning of the nets was not directed by NMFS; therefore, the number of times the try net would be positioned in front of a standard or a TED-equipped net was not randomly determined. In reviewing all of the data, of a total of 403 paired tows in which a try net was involved, 230 (57%) of these had the try net positioned in front of the standard net, while only 173 (43%) were positioned in front of the TED-equipped net (Table 1). The effect of the try net on the catch rate of other nets being towed is unknown. The overall mean catch rates of shrimp and fish combined for standard and TED-equipped nets appeared to be affected similarly by the try net (Table 2, Appendix I Table 2). The mean CPUE's for standard and TED-equipped nets trailing the try net were increased by 5% and 6%, respectively, when try net data were included in CPUE computations. However, adding the entire try net catch to the trailing net confounds the data since all of the catch would probably not have ended up in the trailing net in the absence of a try net. For this reason we are reporting results which exclude try net data.

Performance of TED-equipped and Standard Nets. The total number of nets towed was 2,388. The frequency of net tows with each operation code was tabulated by TED type (Appendix I, Tables

3, 4 and 5). Common problems included clogging of the net, twisting of trawl doors and cables, and torn webbing. In the Gulf of Mexico, no problems occurred during 83%, 84% and 85% of the tows for nets equipped with a Georgia TED with funnel, Super Shooter TED with funnel or standard nets, respectively (Table 3). In the Atlantic the values were 95%, 86% and 92% for the same gear types (Table 3). These problems were independent of net type for the Gulf of Mexico (Chi-Square, $P > 0.25$). However, in the Atlantic, problems were dependent on net type (Chi-Square, $P < 0.005$).

<u>Time Between Tows.</u> Fishing time is reduced when delays in resetting trawls occur. Duration of time between successive tows was compared between control tows without TEDs and tows where at least one TED-equipped net was used. Data were not included in the analysis when time between tows included delays unrelated to net performance, such as, running time to the next station location, mechanical failure of vessel, etc. Mean time between tows when only standard nets were used was 0.71 hr (N=74, standard deviation=0.81) compared with 0.57 hr (N=423, standard deviation=0.63) when at least one TED-equipped net was used. Use of TEDs in nets did not increase the time between tows.

<u>CPUE Comparisons With Commercial Shrimp Fleet.</u> Average CPUE of shrimp was calculated by statistical subarea and season for standard nets monitored on commercial vessels participating in the TED observer program and compared to CPUE for standard nets on other commercial vessels fishing in the same areas and

time. Information on non-participating commercial vessels was obtained through interviews by NMFS port agents (Table 4). Standard net CPUEs of commercial vessels with observers were not significantly different ($P = 0.77$) from CPUEs on other commercial vessels. In two of five cases, shrimp catch from standard nets on TED observer vessels had a higher CPUE than standard nets on other commercial vessels. Mean differences ranged from 5.5 lb/hr gain by the TED-equipped nets to an 8.1 lb/hr gain by the standard nets. It is felt that TED observer vessels were representative of other commercial vessels in the fleet fishing in similar places at the same time.

Correlations/Regressions. Correlations of shrimp CPUE between standard and TED-equipped nets were highly significant ($r > 0.97$, $P < 0.0001$) for all data combined or when sorted by TED type. Shrimp CPUE was also significantly correlated with fish CPUE within standard and TED-equipped nets for all data combined and by TED type ($r > 0.18$, $P < 0.0001$). Shrimp CPUE still remained correlated ($r > 0.96$, $P < 0.0001$) when partitioned by area, season and TED type. Correlations between shrimp and fish CPUEs within standard and Ted-equipped nets were not significant for all areas, seasons and TED types sampled. This may be due to unequal sample sizes created by the partitioning of data.

Regression analyses of shrimp catch, shrimp CPUE and fish catch with and without corrections for try nets between TED-equipped and standard nets are summarized in Appendix I, Table 6 by TED type.

Multivariate Paired T-test

Multivariate Paired t-test by Tow. The same methodology used by Watson et al. (1986), Renaud et al. (1990) and discussed by Morrison (1976) to control experimental error rate was used here to test for mean differences between the standard and TED-equipped trawls for shrimp and finfish separately.

Seasons. Multivariate paired t-tests performed on differences in shrimp CPUE were not significant for standard and TED-equipped nets (Georgia and Super Shooter combined) except during winter when TED nets caught 0.38 lb/hr more than standard nets (Table 5). Mean differences in shrimp CPUE during spring, summer, and fall represent very small and nonsignificant losses in TED-equipped nets: 0.12, 0.16, and 0.11 lb/hr, respectively. Mean differences in shrimp CPUE were plotted for each TED type to show the relationship between standard and TED CPUEs by season (Figs. 3 and 4). The fact that these values were small is of practical importance. CPUEs vary between seasons just as abundance of shrimp on the fishery grounds also varies between seasons. Differences due to use of TEDs are so small that they become masked by natural variations in shrimp CPUE.

There were no significant differences in fish CPUE between TED-equipped and standard nets for any season (Georgia and Super Shooter combined). Mean differences in fish CPUE were 11.27, 1.85, 12.32, and 10.38 lb/hr during winter, spring, summer, and fall, respectively. Seasonal mean fish CPUEs for standard nets were 75.77, 59.11, 345.92, and 131.02 lb/hr for winter, spring, summer, and fall, respectively, while those for TED-equipped nets were 64.50, 57.26, 333.59, and 120.63 lb/hr, respectively. This large range may reflect both seasonality and geographic fishing areas since testing was not conducted in all geographic areas during all seasons. Figures 5 and 6 show the mean differences in fish CPUE for each TED type.

Areas. Shrimp catch rates for TED-equipped nets were comparable with those for standard nets (Figs. 7-10). Differences in shrimp CPUE between net types were significant in southwest Florida and northeast Florida. Shrimp catch rates in southwest Florida were 13.92 lb/hr for the standard net and 12.70 lb/hr for the TED-equipped net for a difference of 1.21 lb/hr; however the sample size was extremely small, only 17 paired tows. In contrast, shrimp catch rates for east Florida were 6.39 lb/hr for standard nets and 6.72 lb/hr for TED nets for a slight increase of 0.33 lb/hr in TED nets. Sample size in this area was 65 paired tows. Differences for mean shrimp CPUE in other Gulf of Mexico areas were smaller, ranging from a loss of 0.15 lb/hr to a gain of 0.15 lb/hr. The only other Atlantic area where testing was conducted was North Carolina where the difference in mean shrimp CPUE was only 0.16 lb/hr.

Areal differences may be confounded with those from net type. In our tests, Georgia TEDs with funnels predominated in Texas, Louisiana, and east Florida. Super Shooter TEDs with funnels predominated in North Carolina, southwest Florida, and the Mississippi/Alabama/Florida panhandle region. The effectiveness of the TED type may influence the catch rates of shrimp.

Finfish catch rates differed significantly between TED-equipped and standard nets only in east Florida where the standard nets captured 12.1 lb/hr more than TED-equipped nets (Table 5). The highest fish CPUEs (by area and season) were from summer sampling off North Carolina; 345.92 lb/hr for standard nets and 333.59 lb/hr for nets equipped with Super Shooter TEDs. These values contrast sharply with those for east Florida: 66.33 and 54.21 lb/hr for standard and TED nets (Georgia and Super Shooter combined), respectively. In the Gulf of Mexico fish catch rates ranged from a high of 138.04 and 127.56 lb/hr in Louisiana to a low of 22.55 and 21.95 lb/hr in southwest Florida for standard and TED nets, respectively. These area differences may be affected by dissimilarities in seasonal sampling since all areas were not sampled each season.

Georgia and Super Shooter TEDs With Funnel. Mean shrimp CPUE for standard and Georgia TED-equipped nets was 6.93 lb/hr and 6.98 lb/hr respectively for a slight gain of 0.05 lb/hr in the TED net (Fig. 11). Comparison of standard and Super Shooter TED-equipped nets showed a mean CPUE of 11.36 lb/hr and 11.20 lb/hr, respectively for a slight loss of 0.16 lb/hr with the Super Shooter TED when compared to the standard net. Neither of these differences were significant. Analysis of shrimp data for both Georgia and Super Shooter TEDs combined show a statistically insignificantly mean difference of 0.07 lb/hr between standard and TED-equipped nets. This is equivalent to a loss of only 0.7% in TED-equipped nets or an average loss of 7 lb/100 hr of trawling/net.

No significant reduction in fish catch by either TED type was apparent (Fig. 12). The mean difference in fish CPUE was 10.78 lb/hr between the Georgia TED net (104.43 lb/hr) and standard net (115.22 lb/hr) and 10.09 lb/hr between the Super Shooter TED (274.94 lb/hr) and standard net (285.03 lb/hr). No significant difference was found when data from both TED types were combined. The mean difference in fish CPUE was 10.39 lb/hr for the TED-equipped net (199.52 lb/hr) and standard net (209.91 lb/hr).

Shrimp and Fish Combined. The differences in mean CPUE between standard and TED-equipped nets were not significant (P values greater than 0.5) when finfish and shrimp were tested simultaneously (Table 5). Neither were they significant when analyzed separately by TED type (Georgia and Super Shooter TEDs with funnel). Significant differences in mean CPUEs were observed when data were partitioned by season (winter) and area (east and southwest Florida). However, rejection of the null hypothesis does not indicate which of the two values, that for shrimp or for fish, caused rejection of the null hypothesis.

Other TED Types. A relatively small amount of data was collected using the Georgia TED without a funnel during Phase 2 (Appendix I Table 7). These data along with previously unreported data collected using the Morrison TED and a commercial modification of the NMFS TED are presented here for completeness (Figs 13 and 14). The number of data pairs for standard and TED-equipped nets were 15, 13, and 76 for the Georgia TED without a funnel, Morrison TED, and NMFS-type TED, respectively. Paired t-tests performed on differences in shrimp CPUE between standard and TED-equipped nets were not significant for the Georgia and Morrison TEDs. There was a significant reduction in shrimp CPUE (0.75 lb/hr) for the NMFS-type TED. Note that this device was not the one developed and rigorously tested by NMFS, but rather, a commercially developed TED which utilized some of the same design principles. Fish CPUE differences between standard and TED-equipped nets were not significant for any of these three devices. We recommend larger sample sizes be obtained before drawing conclusions regarding shrimp or fish loss with these TEDs.

Turtle Captures

Thirty turtles (alive or fresh dead) were captured on vessels participating in this study (Table 6 and Fig. 15). They included 18 loggerheads (*Caretta caretta*), 10 Kemp's ridleys (*Lepidochelys kempi*), 1 green (*Chelonia mydas*) and 1 leatherback (*Dermochelys coriacia*). One turtle was captured off Louisiana, 1 off the west coast of Florida, 17 off the east coast of Florida and 11 off North Carolina.

Twenty-seven turtles were caught in standard shrimp trawls, 1 in a try net and 2 in TED-equipped trawls (Table 6). One loggerhead caught in the TED-equipped trawl was prevented from escaping by a crab trap blocking the TED opening. The turtle was released through the mouth of the net. A second loggerhead seen in the body of a TED-equipped trawl was also released from the mouth of the trawl.

Survival of captured turtles was undetermined. Two Ridley and two loggerhead turtles were unconscious when removed from the trawl. All but one loggerhead turtle were revived and released alive. The loggerhead, presumed dead, was painted, tagged and thrown overboard. No painted carcass was reported by the Sea Turtle Stranding and Salvage Network. The remaining 29 turtles were tagged and released alive but their survival rate is unknown.

Catch rates of turtles in standard and TED-equipped nets varied by region and season (Tables 7 and 8). CPUEs in the Atlantic for standard and TED-equipped nets were 0.0375 and 0.0031 turtles/net hr, respectively. In the Gulf of Mexico, the CPUE for standard and TED-equipped nets was 0.0006 and 0.0 turtles/net hr, respectively.

Biological Yield Models

Ricker-type (Ricker, 1975) yield models developed for each of the three major shrimp species show the same basic curve shape (Nance et al. 1989a). The curves shown in Figure 16 are very flat around the region where yield estimates are plotted for current fishing mortality rates (F-multiples = 1.0). Thus, with current fishing patterns and current fishing mortality rates, little increase or decrease in yield is predicted with the minor reductions in F that would be expected due to small losses of shrimp by TEDs.

Yield estimates were calculated in the model by varying the F-multiplier in 2% increments. Since shrimp loss with TED-equipped vs standard nets was less than 2%, the 2% loss rate was used to calculate changes in yield. A decrease of 2% in F (loss of 2% of shrimp catch with a TED-equipped net compared to a standard net) would result in an estimated 0% change in yield in all three of the major shrimp fisheries in the U.S. Gulf of Mexico.

DISCUSSION

This report is based on data collected by NMFS observers during cooperative cruises with shrimp industry participants. Since this was a voluntary program, area and time of sampling could not be controlled, resulting in great imbalances in the data set by region, season and TED type.

Shrimping Effort

A comparison of shrimping effort (paired tows) during the 1988-1989 and 1989-1990 periods, Phases 1 and 2, is presented in Table 9 by TED type, area and season. During Phase 2, we focused our efforts on filling in data gaps present at the end of Phase 1. Extensive data were collected on the Georgia TED with funnel in the Atlantic Ocean off northeast Florida (fall and winter) as well as in the Gulf of Mexico off Louisiana (fall). A new device, the Super Shooter equipped with an accelerator funnel, was tested extensively off North Carolina (summer) and to a limited degree in the Gulf of Mexico during the spring from southwest Florida to Louisiana (spring).

Season

During Phase 2, Georgia TED tests occurred during fall and winter while Super Shooter tests were conducted almost entirely in the summer. Data were collected during the peak fall shrimping season off Louisiana and east Florida and during the peak summer season off North Carolina. Samples were collected during all seasons in Phase 1 (Table 9).

Gear Performance

Although there are areas within the Gulf and Atlantic where tow problems are more frequent, for example, the rough bottom areas on Florida's Tortugas fishing grounds, our sampling effort did not cover all these areas. Problems were more random than systematic and occurred in both standard and TED-equipped nets.

There was a high degree of similarity in gear performance between these types of nets during both Phases of the study. Variation in the performance of nets was more similar within a Phase than between Phases. During Phase 1, the frequency of net tows without problems was greater than that in Phase 2. In the Gulf of Mexico, no problems occurred during 87% and 90 % of the net tows for Georgia TED-equipped nets and standard nets, respectively, in Phase 1. These values were 83%, 84% and 85% of the net tows for the Georgia TED with funnel, Super Shooter with funnel and standard nets, respectively, during Phase 2. In the Atlantic, no towing problems occurred in Phase 1 92% and 97% of the time in TED-equipped and standard nets respectively while values were 95%, 86% and 92% for the Georgia TED with funnel, Super Shooter with funnel and standard nets, respectively during Phase 2. The problems were not dependent on net type in the Gulf of Mexico (Chi-Square, $P > 0.25$), but were dependent on net type (Chi-Square, $P < 0.005$) in the Atlantic.

The comparison of shrimp CPUE between standard and TED-equipped nets for Phases 1 and 2 was notable. Overall the TEDs performed better during Phase 2, 0.7% shrimp loss, compared to a

10.0% shrimp loss during Phase 1. This may have been due to shrimpers having had up to a year's experience with TEDs and/or the use of a superior TED device (Supper Shooter TED with accelerator funnel replaced Georgia TED without funnel). Shrimp CPUE in TED-equipped nets and standard nets were compared by season, TED type and area for Phases 1 and 2 of the study (Table 10).

CPUE Comparison With the Commercial Fleet

During Phase 1, average shrimp catch per unit effort (CPUE) of observer boats ranged from -38% to +56% of the CPUE of the commercial fleet for given areas and times. In Phase 2 the range was very similar, -34% to +45%. Thus, CPUEs of the commercial fleet fall well within the range of our CPUEs from observer vessels. Considering that relatively few observer trips were made in each area, shrimp catch rates on observer and commercial vessels were generally comparable. Our sampling efforts were representative of commercial shrimping at that time and for that given area. Results of this program are meaningful in terms of evaluation of TEDs under commercial conditions.

Shrimp Fishing Effort

Shrimp fishing effort in the U.S. Gulf of Mexico increased from 170,500 24 hour fishing days in 1981 to a high of 250,300 24 hour fishing days in 1987. Effort decreased to 217,700 days in 1989 (Fig. 17). In contrast, shrimp fishing effort off the U.S. Atlantic coast fluctuated widely from 1981-1989 with a low of 15,700 fishing days in 1985 to a high of 28,900 days in 1989

(Fig. 18).

Turtle Capture

Catch rates of turtles in standard and TED-equipped nets varied by region and season (Tables 7 and 8). CPUEs in the Atlantic for standard and TED-equipped nets were 0.0375 and 0.0031 turtles/net hr, respectively. In the Gulf of Mexico, the CPUE for standard and TED-equipped nets was 0.0006 and 0.0 turtles/net hr respectively. These data indicate that TEDs reduce the capture of turtles by commercial shrimp trawlers.

Some turtles captured by and released from shrimp vessels may strand on beaches. Frequency of strandings for the southern Atlantic coast of the U.S., western Louisiana and Texas (Statistical subareas 17-21) are shown in Figure 19. The turtle strandings were found to increase at the onset of the shrimping season and decrease after closure of the season (Hillestad et al., 1978; Talbert et al., 1980; Ruckdeschel and Zug, 1982; Booker and Ehrhart, 1989; Schroeder and Maley, 1989). Caillouet et al.[5,6] found significant correlations between shrimp fishing effort and turtle strandings in Statistical Areas 17-21 of the northwestern Gulf of Mexico.

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[5]Caillouet, C.W., Jr. M. J. Duronslet, A. M. Landry, Jr., D. B. Revera, D. J Shaver, K. M. Stanley, E. K. Stabenau and R. W. Heinly. 1991. Sea turtle strandings and shrimp fishing effort in the northwestern Gulf of Mexico, 1986-1989. Manuscript submitted to U. S. Fishery Bulletin.

[6]Caillouet, C.W., Jr. M. J. Duronslet, A. M. Landry, Jr.,and D. J Shaver. 1991. Sea turtle strandings and shrimping effort on coasts of southwestern Louisiana and Texas. Paper presented at the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, Jekyll Island, Georgia.

Biological Model

Shrimp catch rates in TED-equipped nets were 0.7% lower than those in standard nets with mean rates varying from a gain of 0.7% with Georgia TEDs to a loss of 1.4% with Super Shooter TEDs. Although the difference of 0.7% was not statistically significant, we used mathematical models to determine what this loss rate would mean to total production in the shrimp fisheries. Yield curves were generated for each of the shrimp fisheries by using models to determine total yield with a variety of different fishing pressures. The present level of fishing effort (F-multiplier = 1.0) intersects each curve at a point along a broad plateau (Nance et al., 1989b). Because of the flat-topped nature of these curves, at the present level of fishing, an increase in fishing mortality rates would not increase the yield of shrimp. Likewise, a decrease in fishing mortality rates of 2% (the smallest increment used in the model) would not decrease the production of shrimp. Slight decreases in yield would be observed in some shrimp fisheries if loss rates from TED's were in the 10-20% range. With the 10% loss rate we observed from TED's during Phase 1 of the study we calculated a loss only from the pink shrimp fishery of 2-4%; no decreases in yield were observed in either the white or brown shrimp fisheries.

We have assumed 1) that a shrimp escaping through either a TED-equipped net or a standard net will not die because of that episode (no increase in natural mortality rates), and 2) that such escaping shrimp will join the remaining population, and will grow and experience the same natural mortality as the rest of the stock. Phares (1978), describing the selectivity of shrimp nets, showed a loss rate of shrimp varying by area and season, with an extensive size range of lost shrimp. Therefore, we have assumed that mortality incurred by shrimp escaping from TED-equipped nets would be no greater than that experienced from standard nets. In fact, the survival rate of shrimp escaping from TED-equipped nets might be increased because the opening in the TED-equipped net is larger than the mesh openings in the cod end of a standard net. If there were a decrease of 2% in the catch rate and this translated to a fishing mortality decrease of 2%, we would estimate a resultant decrease in yield of 0% in the white, brown, and pink shrimp fisheries. By this we mean that there is ample fishing effort on the grounds to capture the animals for that given year-class, and that a reduction in the fishing mortality rate due to loss of shrimp by TEDs will not greatly affect the yield. Although this decrease may, in fact, impact a given individual fisherman on any particular tow, what he loses in that tow will still be available to him and others for capture by succeeding tows that day or the next and might even be accessible to him within the next couple of months.

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Table 1. Number of tows in which try net was in front of standard or TED-equipped nets; all TED types combined.

	Number	%
Standard	230	57
TED	173	43
Total	403	

Table 2. Comparison of mean CPUE (lb/hr) with and without try net for standard and TED-equipped nets; all TED types combined.

	Mean CPUE (lb/hr)		
	Without try net	With try net	% diff
Standard net	9.4	9.9	5
TED net	9.3	9.9	6

Table 3. Comparison of net types with and without gear related problems by area and TED type. Problems were not dependent on net type in the Gulf of Mexico (Chi-Square, $P > 0.25$), but were dependent on net type (Chi-Square, $P < 0.005$) in the Atlantic. Values represent the percent of nets in each category

GULF OF MEXICO

	Georgia TED with funnel (n=317)	Super Shooter TED with funnel (n=137)	Standard Net (n=710)
No problems	83	84	85
Clogging, choking	6	7	6
Doors, cables	6	2	4
Torn webbing	4	2	3
Other	1	5	2

ATLANTIC

	Georgia TED with funnel (n=148)	Super Shooter TED with funnel (n=433)	Standard Net (n=728)
No problems	95	86	92
Clogging, choking	4	7	3
Doors, cables	1	4	4
Torn webbing	0	3	1

Table 4. CPUE (lbs/hr/4 nets) comparisons of shrimp catch rates in standard nets; TED project vs commercial (Phase 2); by season and statistical area. Data are from 7 trips on observer vessels in the Gulf of Mexico and interviews of the commercial shrimp fleet. If a trip encompassed more than one group of statistical areas or overlapped both groups of seasons then the data were partitioned into the appropriate groups and the trip was counted once in each group.

Season	Statistical Area	Data Type	Number of trips	CPUE $\pm$ Standard Error (lbs/hr)
Summer-Fall	9-12	**TED Project**	3	22.8 $\pm$ 0.42
Summer-Fall	9-12	Commercial	283	14.6 $\pm$ 0.03
Summer-Fall	13-17	TED Project	6	14.7 $\pm$ 0.20
Summer-Fall	13-17	Commercial	1538	18.6 $\pm$ 0.02
Summer-Fall	18-21	TED Project	14	23.4 $\pm$ 0.15
Summer-Fall	18-21	Commercial	3804	18.8 $\pm$ 0.01
Winter-Spring	1-8	TED Project	6	16.7 $\pm$ 0.27
Winter-Spring	1-8	Commercial	1221	15.3 $\pm$ 0.02
Winter-Spring	9-12	TED Project	3	8.9 $\pm$ 0.14
Winter-Spring	9-12	Commercial	162	8.4 $\pm$ 0.05
Winter-Spring	13-17	TED Project	4	10.7 $\pm$ 0.15
Winter-Spring	13-17	Commercial	739	12.1 $\pm$ 0.03
Winter-Spring	18-21	TED Project	3	6.5 $\pm$ 0.65
Winter-Spring	18-21	Commercial	1601	10.4 $\pm$ 0.02

able 5. Results of multivariate paired t-test for all data without try nets included. Comparisons between CPUE (lb/hr) of standard and TED-equipped nets by tow[a].

		P Values					Difference (std-TED) between Mean CPUEs (lbs/hr)			
	N TOWS	CPUE (lb/hr) shrimp & fish	CPUE (lb/hr) shrimp	CPUE (lb/hr) fish	Mean CPUE (lb/hr) shrimp std. net	Mean CPUE (lb/hr) shrimp TED net	shrimp	shrimp (%)	fish	fish (%)
'erall	425	0.55	0.78	0.62	9.40	9.33	0.07	(+1)[b]	10.39	(+5)
:D type										
GA/F[c]	188	0.15	0.87	0.20	6.93	6.98	-0.05	(-1)	10.78	(+9)
SS/F[d]	237	0.56	0.58	0.86	11.36	11.20	0.16	(+1)	10.09	(+4)
nths										
Dec-Feb	58	<0.01	<0.01	0.18	5.74	6.12	-0.38	(-7)	11.27	(+15)
Mar-May	48	0.69	0.81	0.89	8.70	8.57	0.12	(+1)	1.85	(+3)
Jun-Aug	187	0.66	0.70	0.87	11.99	11.83	0.16	(+1)	12.32	(+4)
Sep-Nov	132	0.36	0.69	0.44	7.60	7.49	0.11	(+1)	10.38	(+8)
eas										
1-8	17	<0.01	<0.01	0.96	13.92	12.70	1.21	(+9)	0.60	(+3)
9-12	13	0.11	0.62	0.12	4.11	4.27	-0.15	(-4)	-11.94	(-15)
13-17	133	0.44	1.00	0.45	7.64	7.65	0.00	(0)	10.48	(+8)

able 5. (cont).

	N TOWS	P Values: CPUE (lb/hr) shrimp & fish	P Values: CPUE (lb/hr) shrimp	P Values: CPUE (lb/hr) fish	Mean CPUE (lb/hr) shrimp std. net	Mean CPUE (lb/hr) shrimp TED net	Difference (std-TED) between Mean CPUEs (lbs/hr): shrimp	shrimp (%)	fish	fish (%)
reas										
18-21	10	0.34	0.60	0.42	3.10	2.95	0.15	(+5)	7.57	(+19)
30-32	65	<0.01	<0.01	0.02	6.39	6.72	-0.33	(-5)	12.12	(+18)
34-35	187	0.66	0.70	0.87	11.99	11.83	0.16	(+1)	12.32	(+4)
ay/Night										
Day	158	0.11	0.98	0.15	9.43	9.46	-0.03	(0)	19.44	(+13)
Night	171	0.58	0.74	0.70	8.72	8.62	0.11	(+1)	14.50	(+6)
Both	96	0.71	0.81	0.93	10.56	10.41	0.15	(+1)	-11.81	(-4)

Numbers with decimals are rounded to nearest 0.01.
Positive indicates higher catch in standard nets; negative indicates higher catch in TED nets.
Georgia TED with funnel.
Super shooter TED with funnel.

Table 6. Turtle captures by area, net type and species.

Net Type	LA	W. FL	E. FL	NC
Standard Net	1	0	17	9
Try net	0	1	0	0
TED-equipped net	0	0	0	2
Totals	1	1	17	11

Species	LA	W. FL	E. FL	NC
Loggerhead	0	1	9	8
Kemp's ridley	1	0	7	2
Green	0	0	0	1
Leatherback	0	0	1	0
Totals	1	1	17	11

Table 7. Standard net data: observer effort, turtle captures, CPUE (turtles/hr), estimated captures of sea turtles in the U. S. Gulf of Mexico and Atlantic by season for September 1989 through August 1990. Annual commercial shrimping effort data are for 1989.

Area	Season	Number of Tows	Standardized Headrope Effort (hrs)	Captured Turtles	Estimated CPUE (turtles/net hour)
Atlantic	Winter	40	112	6	0.0537
	Spring	0			
	Summer	238	449	8	0.0178
	Fall	64	133	12	0.0900
Combined		342	694	26	0.0375
Gulf of Mexico:					
Stats 1-7 (eastern)	Winter	2	18	0	
	Spring	49	175	0	
	Summer	0			
	Fall	0			
	Combined	51	193	0	
Stats 8-17 (central)	Winter	37	245	0	
	Spring	42	215	0	
	Summer	11	26	0	
	Fall	136	590	1	0.0017
	Combined	226	1076	1	0.0009
Stats 18-21 (western)	Winter	0			
	Spring	0			
	Summer	53	117	0	
	Fall	35	246	0	
	Combined	88	363	0	
Gulf Combined		365	1632	1	0.0006

Table 8. TED net data: observer effort, turtle captures, CPUE (turtles/hr), estimated captures of sea turtles in the U. S. Gulf of Mexico and Atlantic by season for September 1989 through August 1990. Annual commercial shrimping effort data are for 1989.

Area	Season	Number of Tows	Standardized Headrope Effort (hrs)	Captured Turtles	Estimated CPUE (turtles/net hour)
Atlantic	Winter	40	109	0	
	Spring	0			
	Summer	238	432	2	0.0046
	Fall	64	105	0	
	Combined	342	646	2	0.0031
Gulf of Mexico:					
Stats 1-7 (eastern)	Winter	2	18	0	
	Spring	49	212	0	
	Summer	0			
	Fall	0			
	Combined	51	230	0	
Stats 8-17 (central)	Winter	37	233	0	
	Spring	42	201	0	
	Summer	11	23	0	
	Fall	136	616	0	
	Combined	226	1073	0	
Stats 18-21 (western)	Winter	0			
	Spring	0			
	Summer	53	176	0	
	Fall	35	228	0	
	Combined	88	404	0	
Gulf Combined		365	1707	0	

Table 9. Number of paired tows by TED type, area and season for the 1988-1989 and 1989-1990 data bases.

Paired Tows
(1988-1989 / 1989-1990)

Georgia TED (with funnel)	Winter	Spring	Summer	Fall
Texas	3/0	1/0	88/02	0/0
Louisiana	34/26	55/0	25/0	19/85
Ms/Al/FlPan	28/0	3/0	20/0	37/2
SW Fl	17/0	79/0	0/0	0/0
Fl Atl	0/30	0/0	21/0	0/35
Totals	82/56	138/0	154/0	82/132

Georgia TED (no funnel)	Winter	Spring	Summer	Fall
Louisiana	0/0	0/0	21/0	0/0
SW Fl	0/0	10/0	0/0	0/0
Fl Atl	60/0	0/0	165/0	0/0
Totals	60/0	10/0	186/0	0/0

Super Shooter TED with funnel	Winter	Spring	Summer	Fall
Louisiana	0/0	0/22	0/0	0/0
Ms/Al/FlPan	0/0	0/11	0/0	0/0
SW Fl	0/2	0/15	0/0	0/0
NC	0/0	0/0	0/187	0/0
Totals	0/2	0/48	0/187	0/0

Table 10. Comparison of shrimping effort (paired tows) and shrimp CPUE (lb/hr) of standard and TED-equipped nets by tow[a] (Phase 1 data/Phase 2 data); try net information not included.

	N TOWS	Mean CPUE (lb/hr) shrimp std. net	Mean CPUE (lb/hr) shrimp TED net	Difference (std-TED) between Mean CPUEs (lbs/hr) shrimp	(%)
Overall	706/425	6.53/9.40	5.88/9.33	0.6/0.07	+10/+1
TED type					
GA/F[c]	450/188	6.33/6.93	5.85/6.98	0.5/-0.05	+8/-1
SS/F[d]	---/237	----/11.36	----/11.20	---/0.16	---/+1
GA/NF[e]	256/---	6.87/----	5.93/----	0.9/----	+14/--
Months					
Dec-Feb	142/58	3.83/5.74	3.92/6.12	-0.1/-0.38	-2/-7
Mar-May	148/48	4.62/8.70	3.95/8.57	0.7/0.12	+15/+1
Jun-Aug	340/187	8.37/11.99	7.45/11.83	0.9/0.16	+11/+1
Sep-Nov	76/132	7.04/7.60	6.29/7.49	0.7/0.11	+11/+1
Areas					
1-8	106/17	5.30/13.92	4.62/12.70	0.7/1.21	+13/+9
9-12	88/13	7.40/4.11	7.04/4.27	0.4/-0.15	+5/-4
13-17	154/133	4.81/7.64	4.43/7.65	0.4/0.00	+8/0

Table 10 (cont.)

	N TOWS	Mean CPUE (lb/hr) shrimp std. net	Mean CPUE (lb/hr) shrimp TED net	Difference (std-TED) between Mean CPUEs (lbs/hr) shrimp	(%)
18-21	112/10	7.13/3.10	6.76/2.95	0.4/0.15	+5/+5
30-32	60/65	4.58/6.39	4.41/6.72	0.2/-0.33	+4/-5
34-35	186/187	8.50/11.99	7.20/11.83	1.3/0.16	+15/+1
Day/Night					
Day	290/158	6.46/9.43	5.69/9.46	0.8/-0.03	+12/0
Night	338/171	6.78/8.72	6.20/8.62	0.6/0.11	+9/+1
Both	78/96	5.69/10.56	5.22/10.41	0.5/0.15	+8/+1

[a] Numbers with decimals are rounded to nearest 0.01.
[b] Positive indicates higher catch in standard nets; negative indicates higher catch in TED nets.
[c] Georgia TED with funnel.
[d] Super shooter TED with funnel.
[e] Georgia TED without a funnel

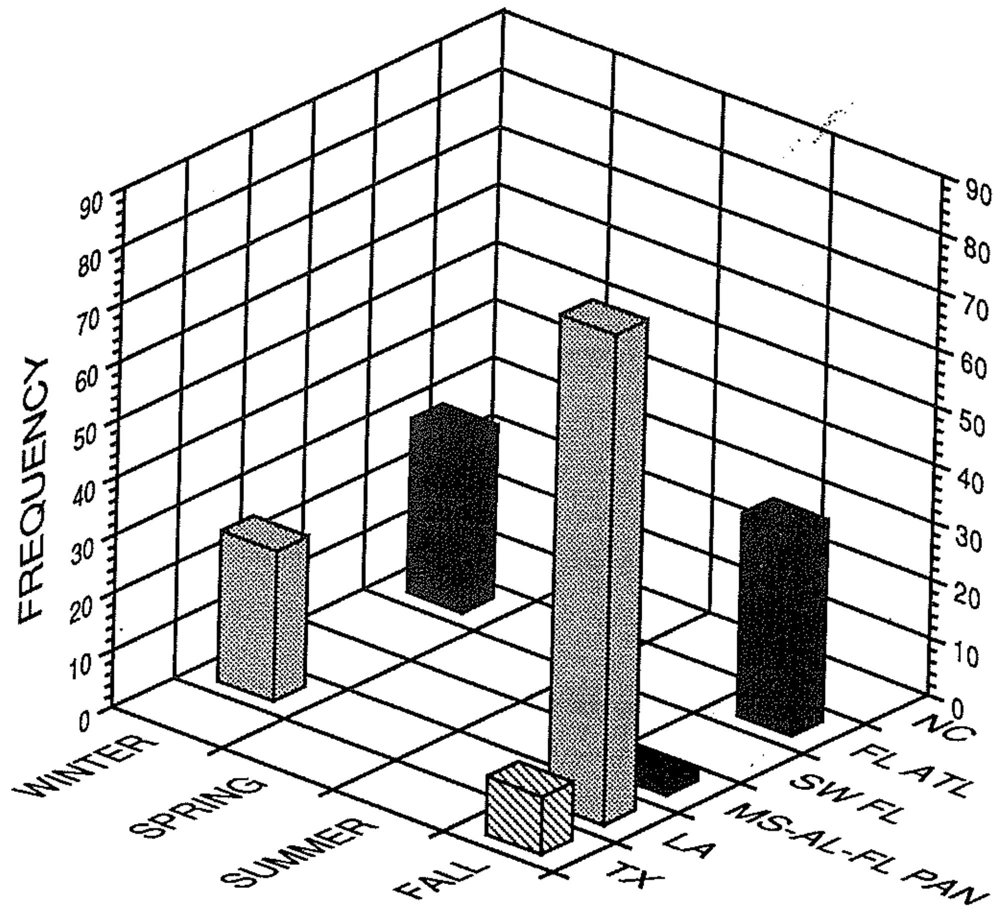


Figure 1. Frequency of paired tows for standard and Georgia TED-equipped nets (with funnel) by season and area (N = 188).

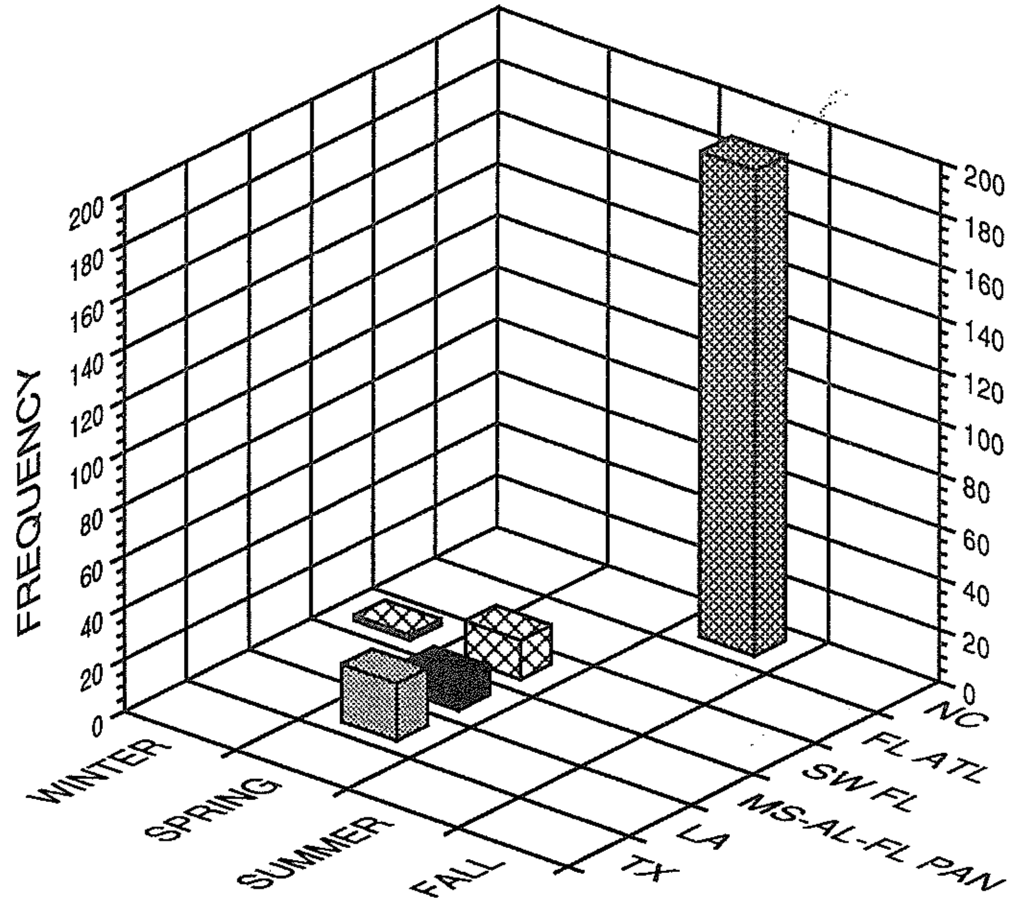


Figure 2. Frequency of paired tows for standard and Super Shooter TED-equipped nets (with funnel) by season and area (N = 237).

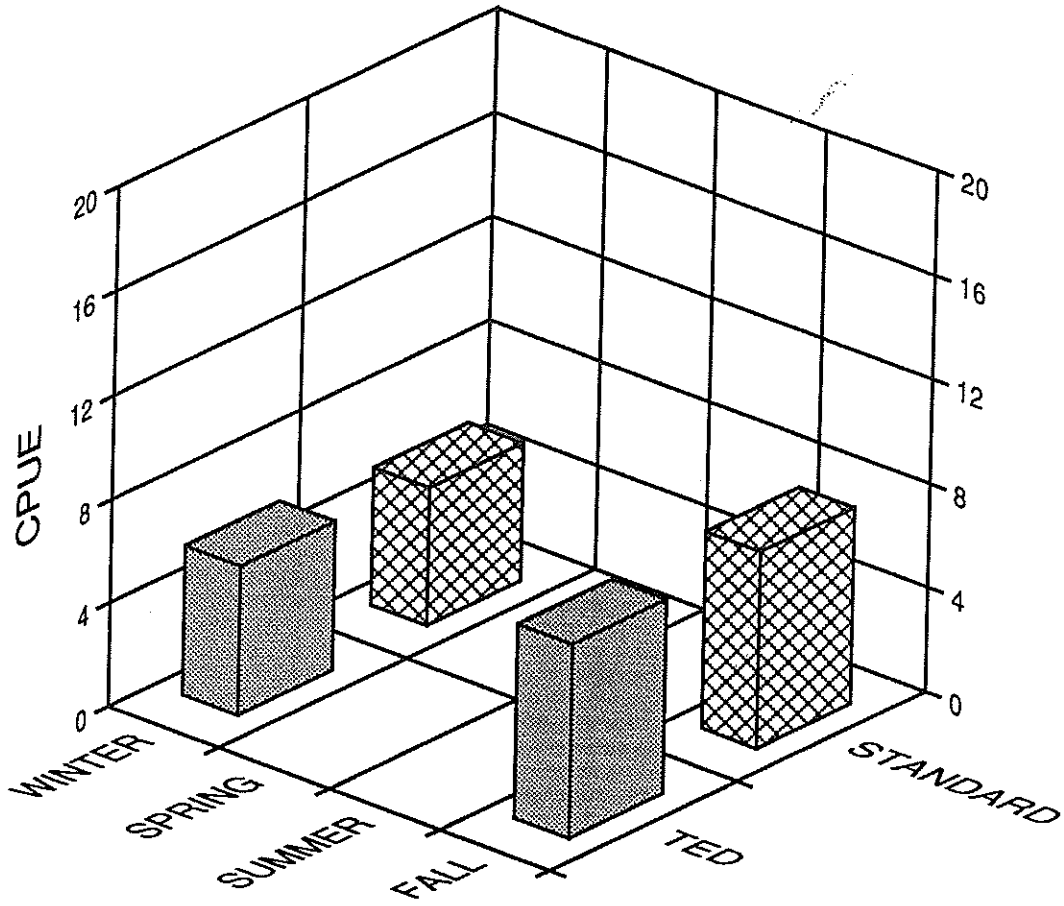


Figure 3. Seasonal comparison of shrimp CPUE (lb/hr) between standard nets and nets equipped with Georgia TEDs with funnels. N values for seasonal data paired by tow are 56, 0, 0, and 132 for winter, spring, summer, and fall, respectively.

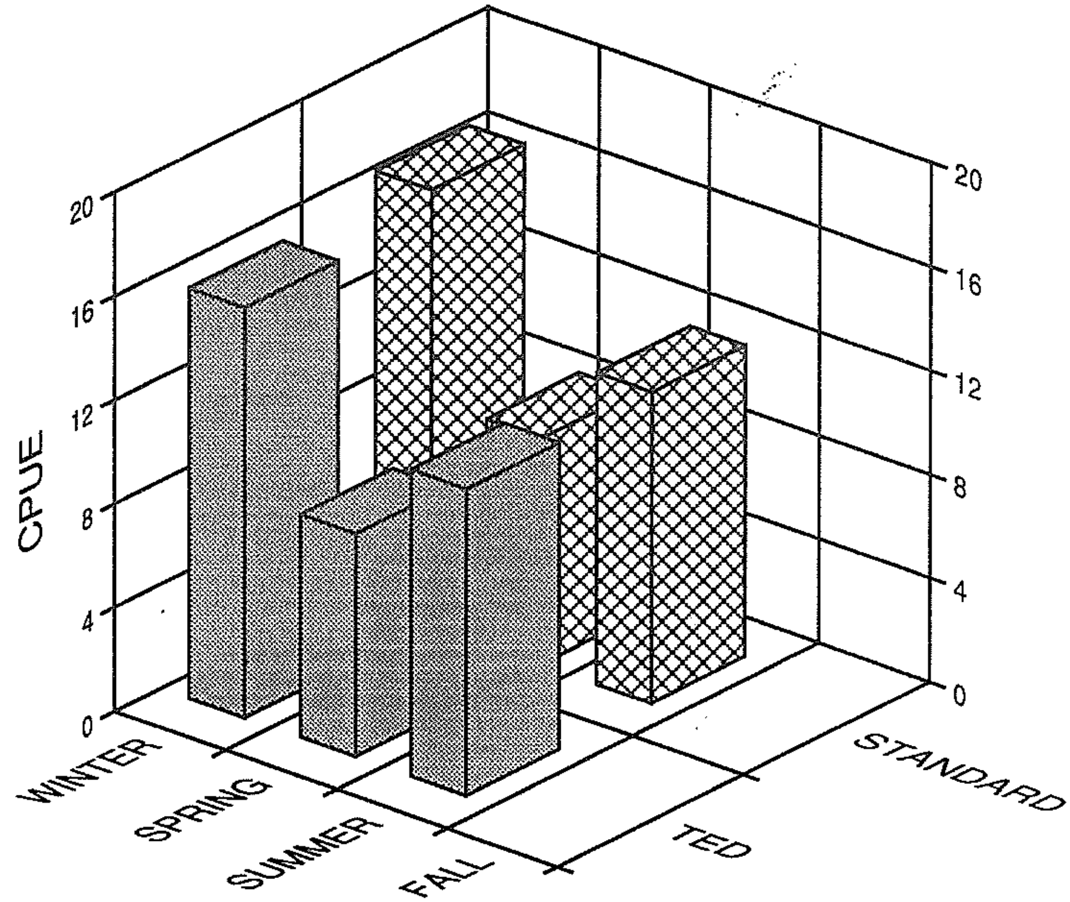


Figure 4. Seasonal comparison of shrimp CPUE (lb/hr) between standard nets and nets equipped with Super Shooter TEDs with funnels. N values for seasonal data paired by tow are 2, 48, 187, and 0 for winter, spring, summer, and fall, respectively.

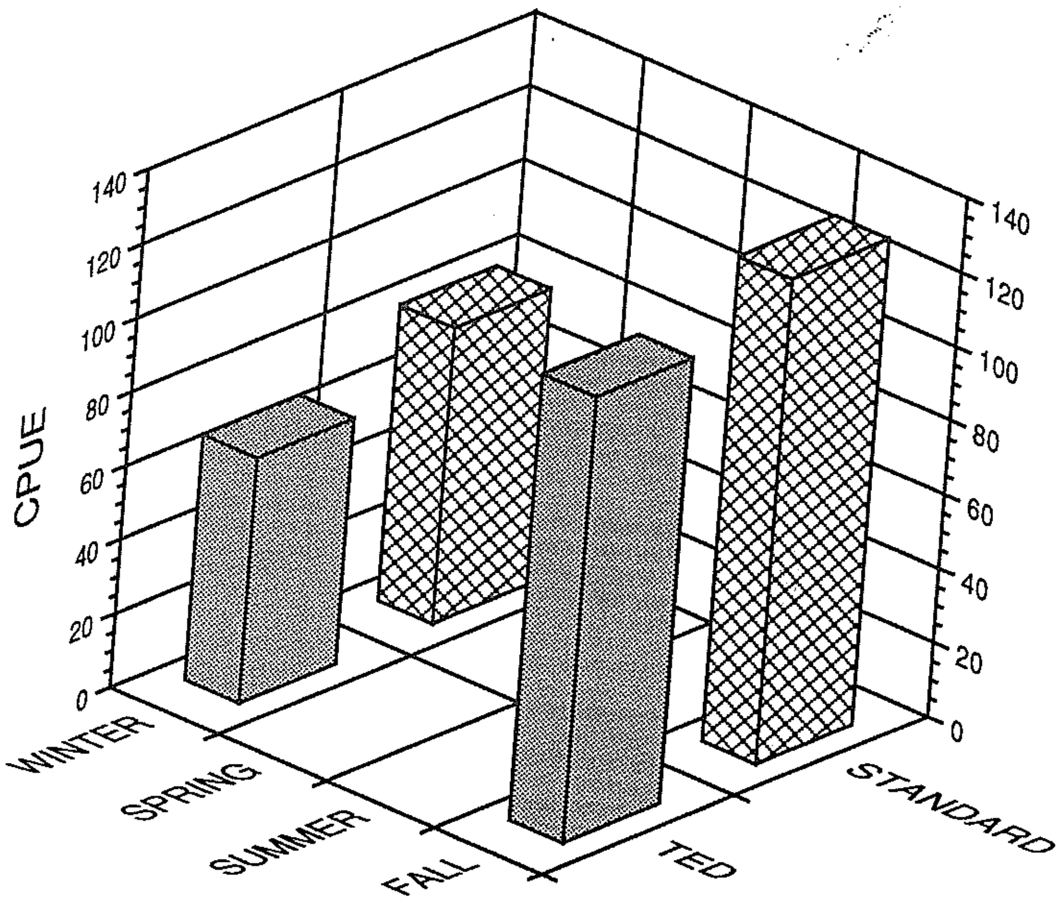


Figure 5. Seasonal comparison of fish CPUE (lb/hr) between standard nets and nets equipped with Georgia TEDs with funnels. N values for seasonal data paired by tow are 56, 0, 0, and 132 for winter, spring, summer, and fall, respectively.

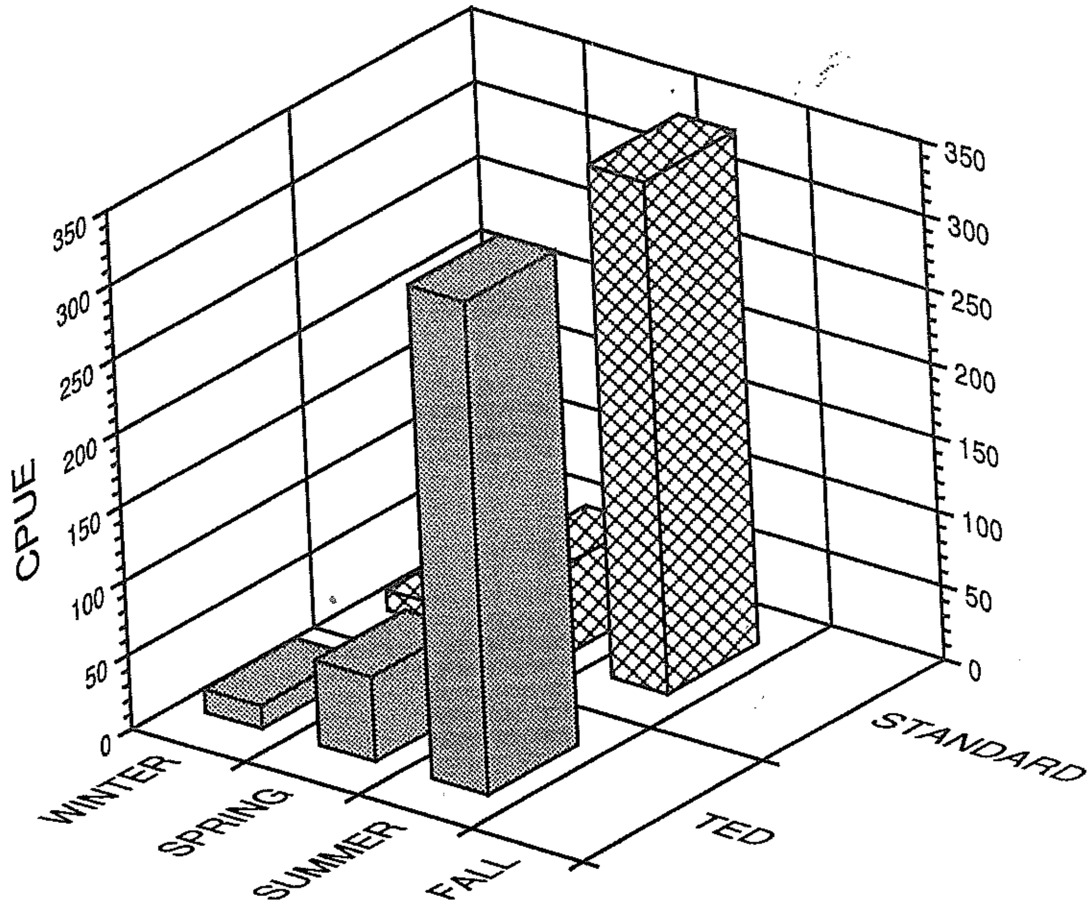


Figure 6. Seasonal comparison of fish CPUE (lb/hr) between standard nets and nets equipped with Super Shooter TEDs with funnels. N values for seasonal data paired by tow are 2, 48, 187, and 0 for winter, spring, summer, and fall, respectively.

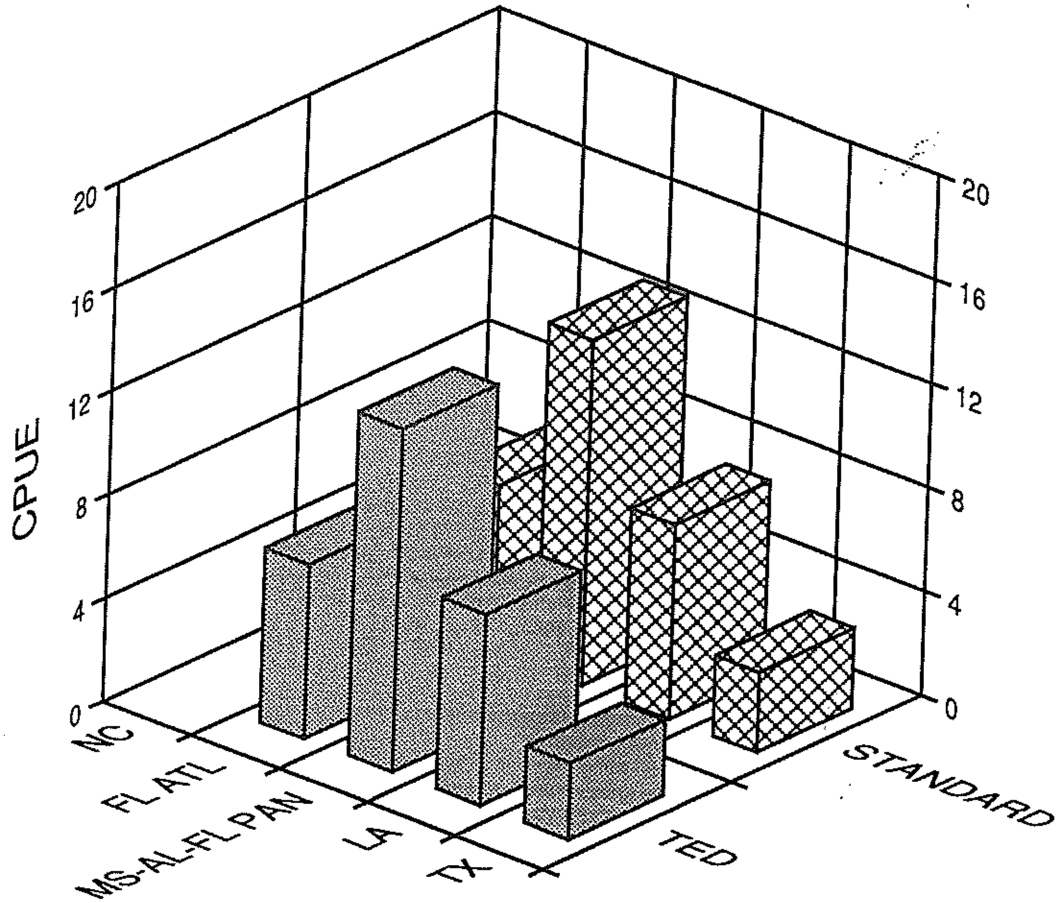


Figure 7. Differences in shrimp CPUE (lb/hr) between standard nets and nets equipped with Georgia TEDs with funnels by area. N values for data paired by tow for each area are 0, 65, 2, 111 and 10 for NC, FL ATLANTIC COAST, MS-AL-FL PANHANDLE, LA and TX respectively.

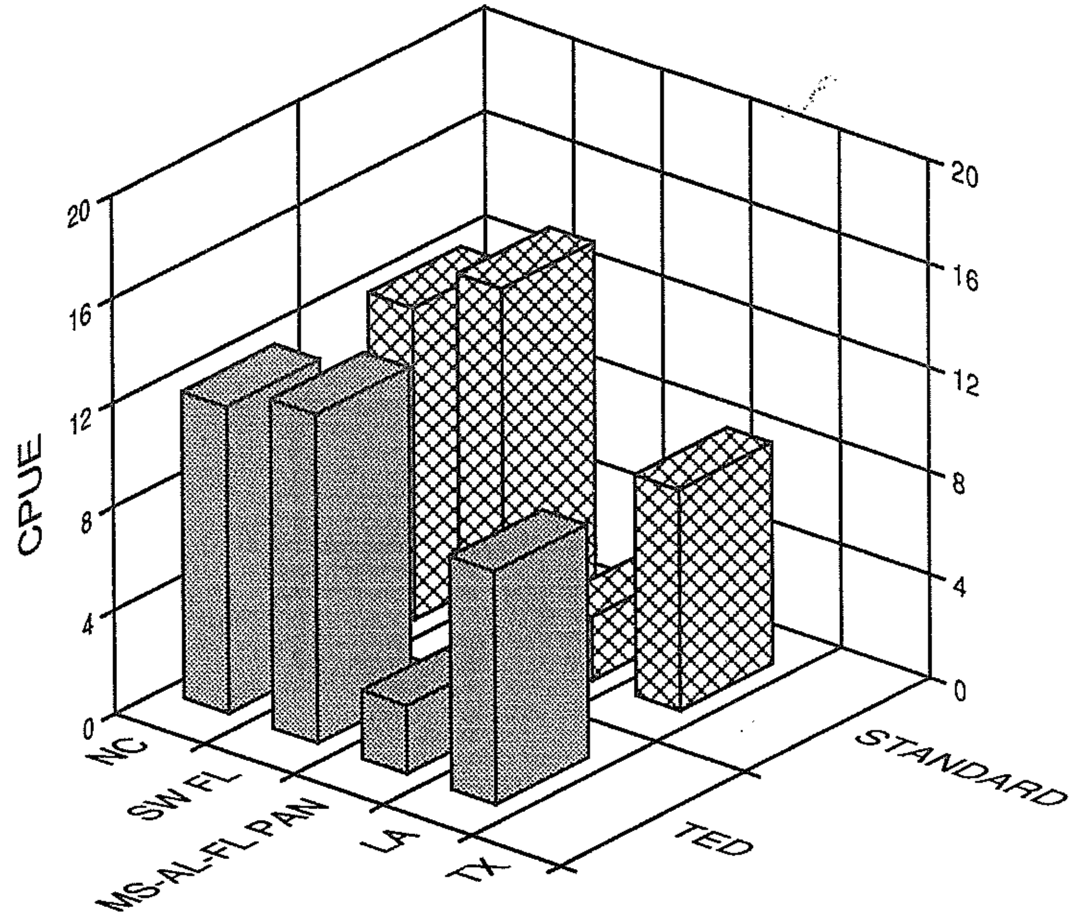


Figure 8. Differences in shrimp CPUE (lb/hr) between standard nets and nets equipped with Super Shooter TEDs with funnels by area. N values for data paired by tow for each area are 187, 17, 11, 22 and 0 for NC, SW FL, MS-AL-FL PANHANDLE, LA and TX respectively.

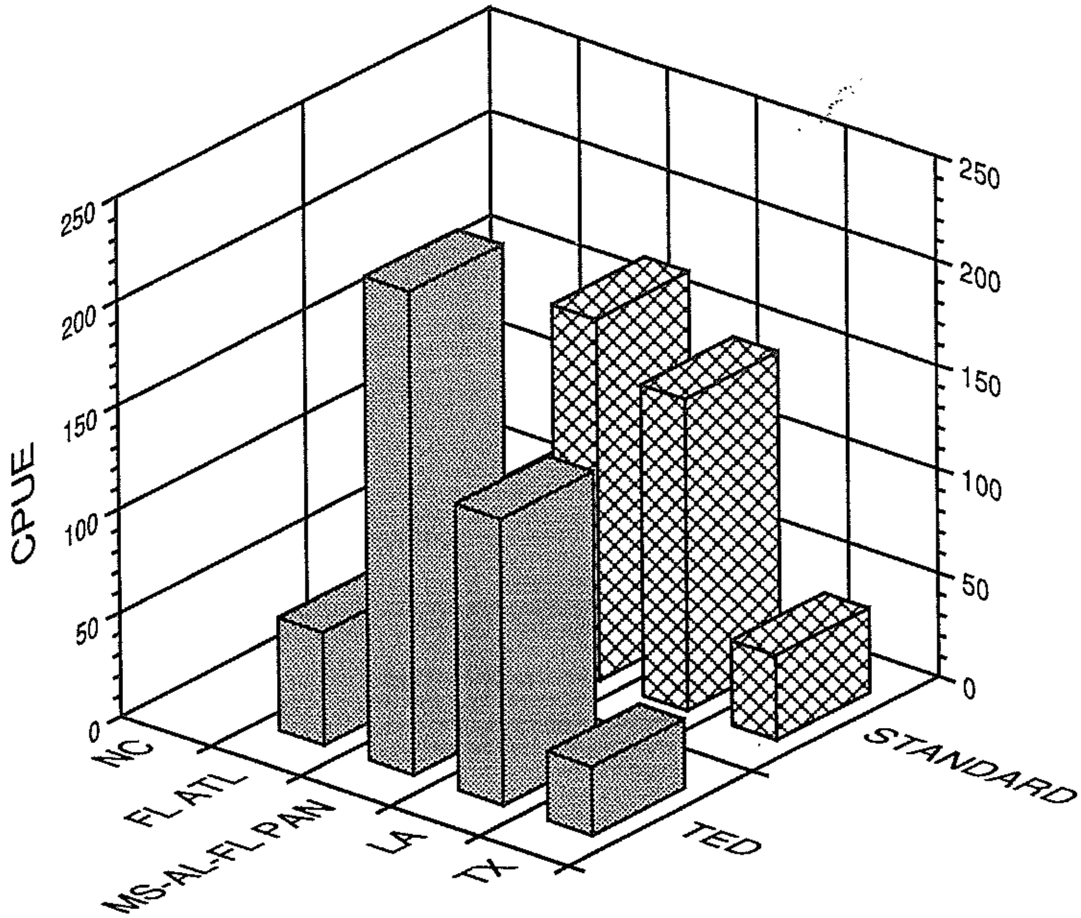


Figure 9. Differences in fish CPUE (lb/hr) between standard nets and nets equipped with Georgia TEDs with funnels by area. N values for data paired by tow for each area are 0, 65, 2, 111 and 10 for NC, FL ATLANTIC COAST, MS-AL-FL PANHANDLE, LA and TX respectively.

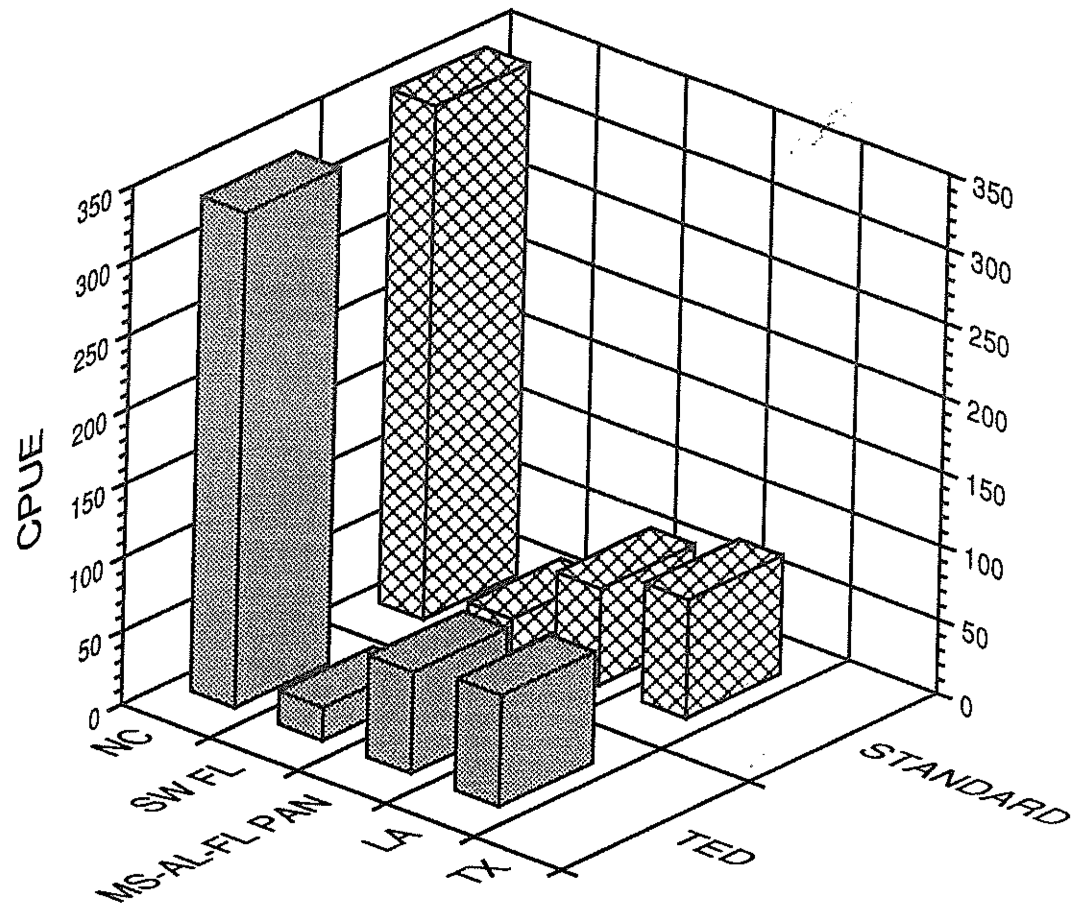


Figure 10. Differences in fish CPUE (lb/hr) between standard nets and nets equipped with Super Shooter TEDs with funnels by area. N values for data paired by tow for each area are 187, 17, 11, 22 and 0 for NC, SW FL, MS-AL-FL PANHANDLE, LA and TX respectively.

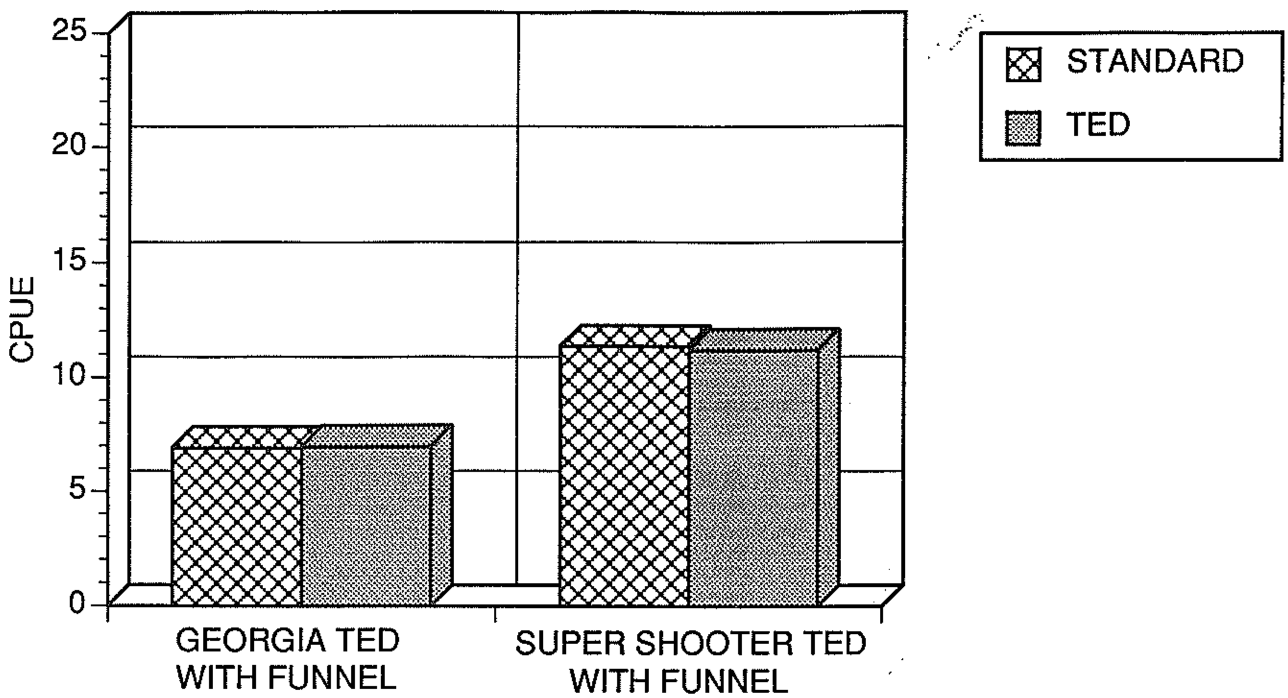


Figure 11. CPUE (lb/hr) of shrimp in standard and TED-equipped nets. All areas and seasons combined. Standard and TED-equipped nets were not significantly different (P<0.05). Data paired by tows without try nets included (n = 425).

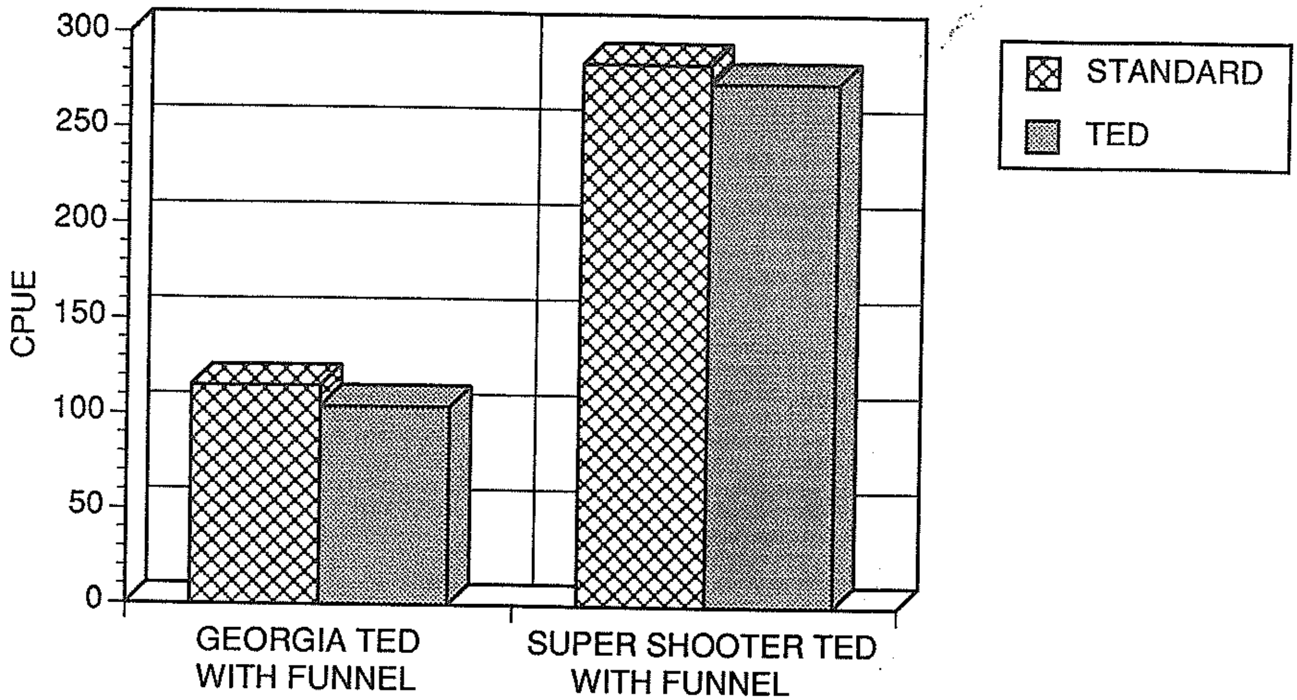


Figure 12. CPUE (lb/hr) of finfish in standard and TED-equipped nets. All areas and seasons combined. Standard and TED-equipped nets were not significantly different (P<0.05). Data paired by tows without try nets included (n = 425).

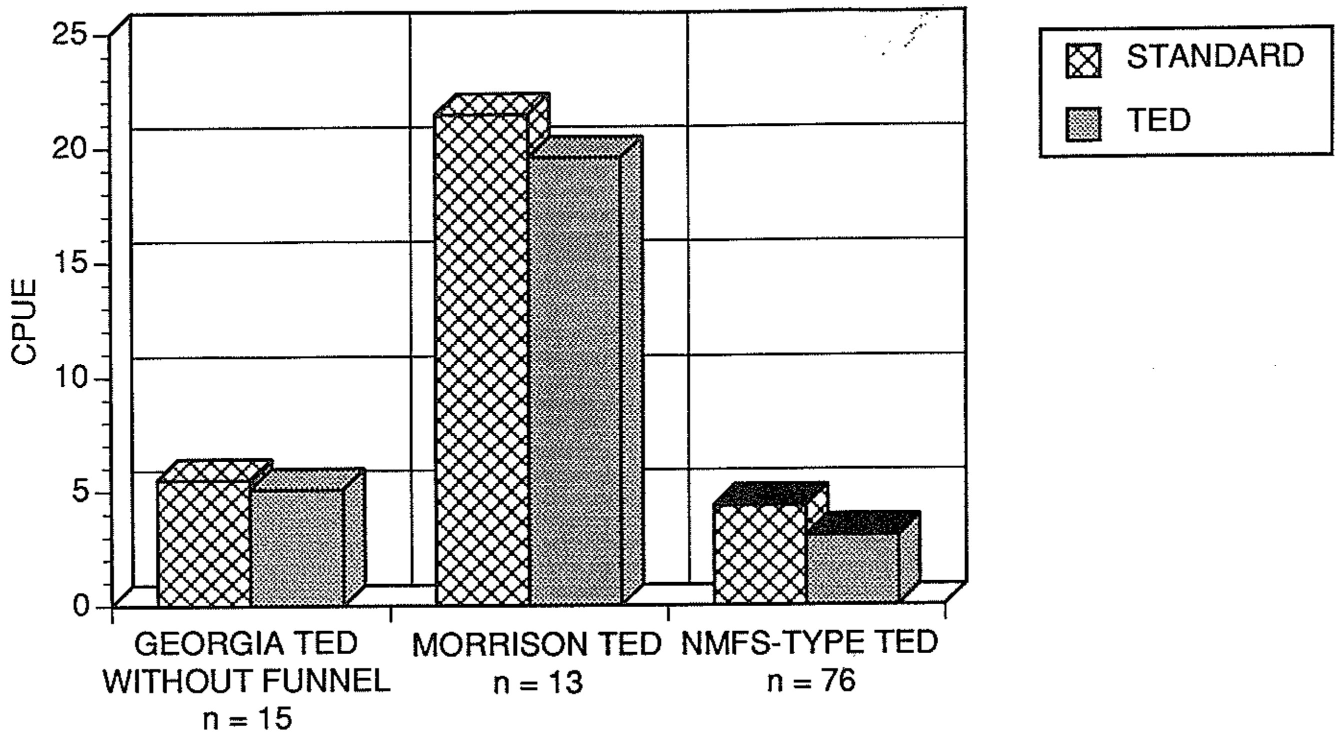


Figure 13. CPUE (lb/hr) of shrimp in standard and TED-equipped nets (Georgia TED without funnel, Morrison TED, NMFS-type TED). All areas and seasons combined. Solid topped bars represent a significant difference between standard and TED-equipped nets ($P<0.05$). Data paired by tows without try nets included.

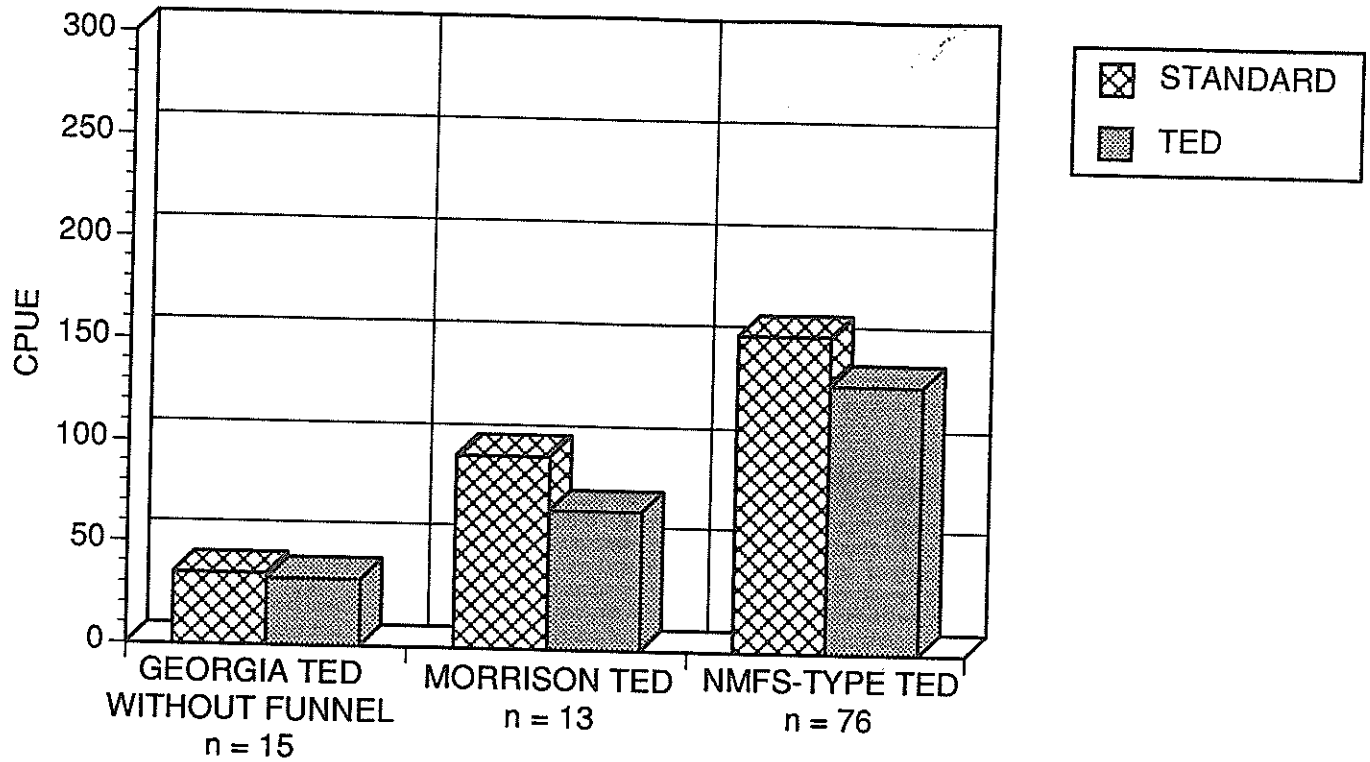


Figure 14. CPUE (lb/hr) of finfish in standard and TED-equipped nets (Georgia TED without funnel, Morrison TED, NMFS-type TED). All areas and seasons combined. Standard and TED-equipped nets were not significantly different ($P<0.05$). Data paired by tows without try nets included.

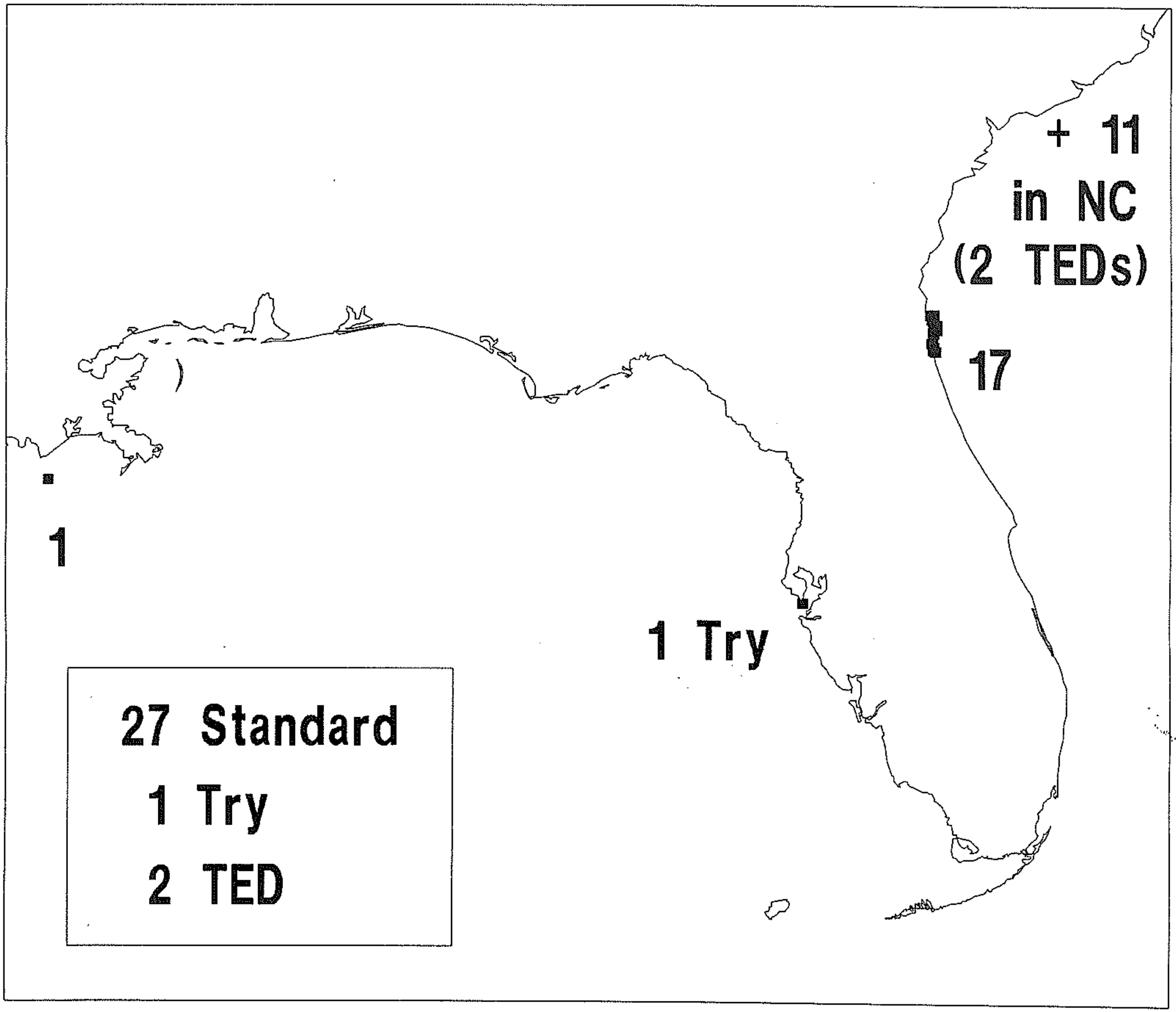


Figure 15. Locations of turtle captures.

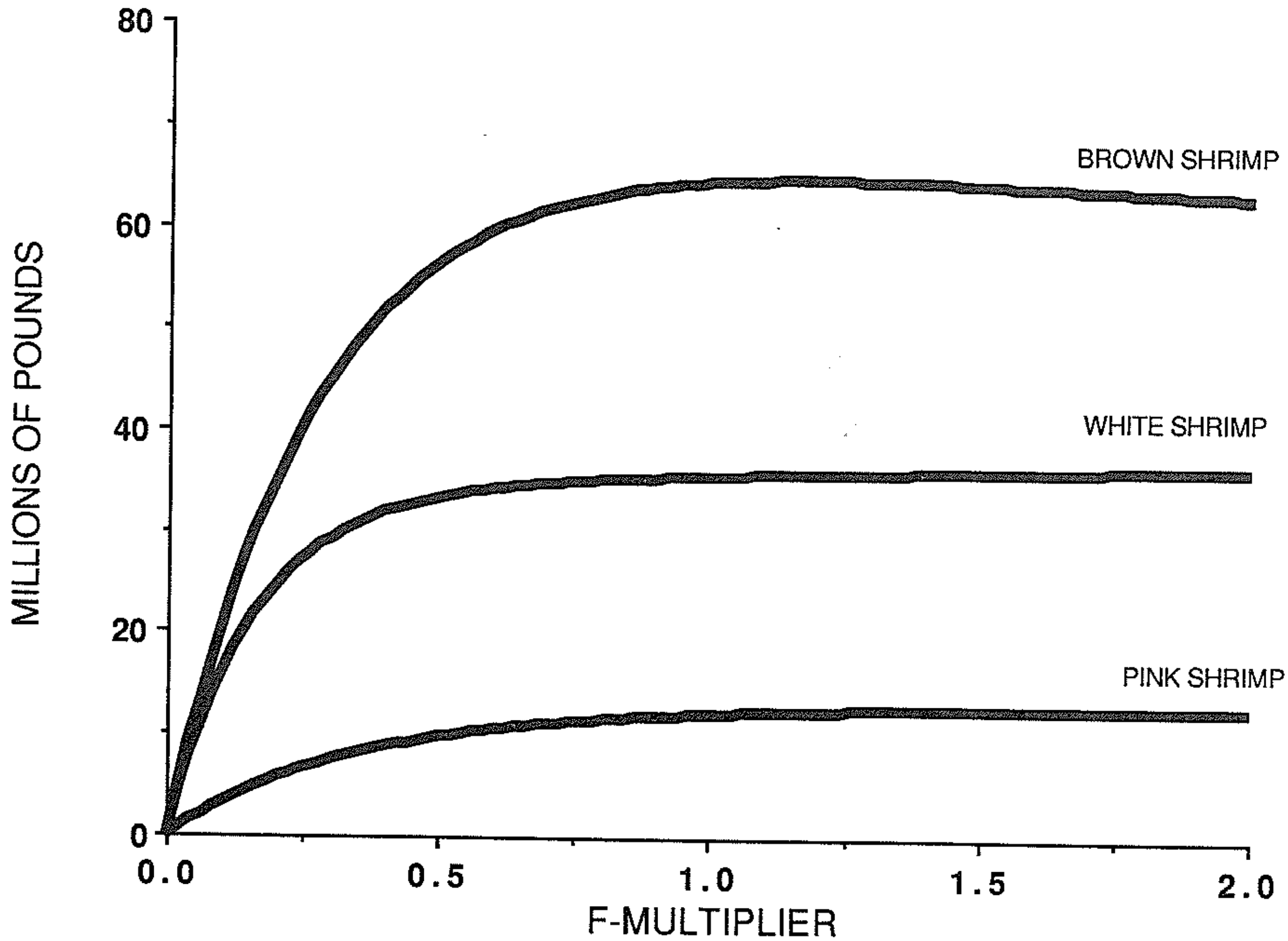


Figure 16. Yield models for brown, white, and pink shrimp.

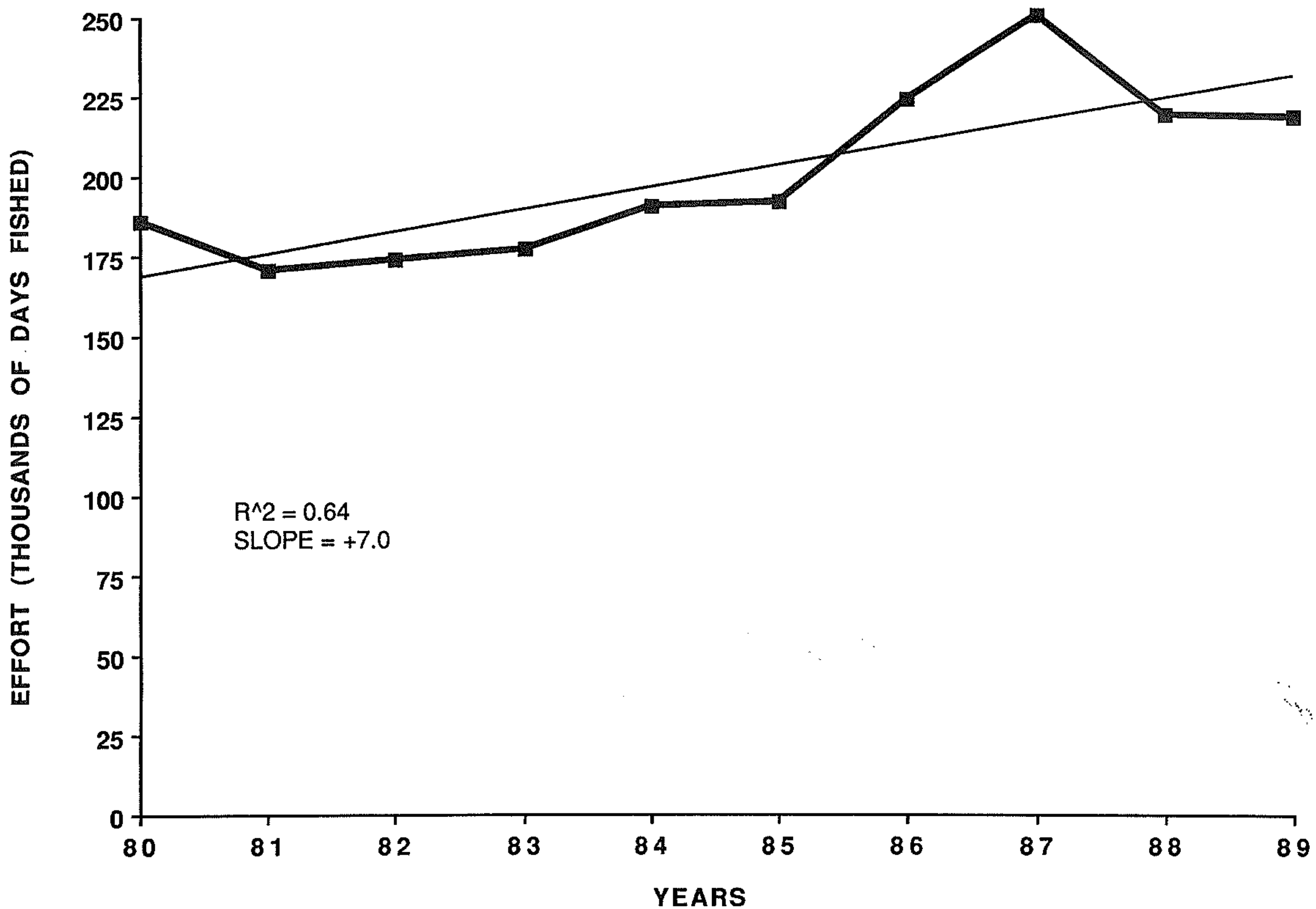


Figure 17. Effort in the offshore Gulf of Mexico shrimp fishery.

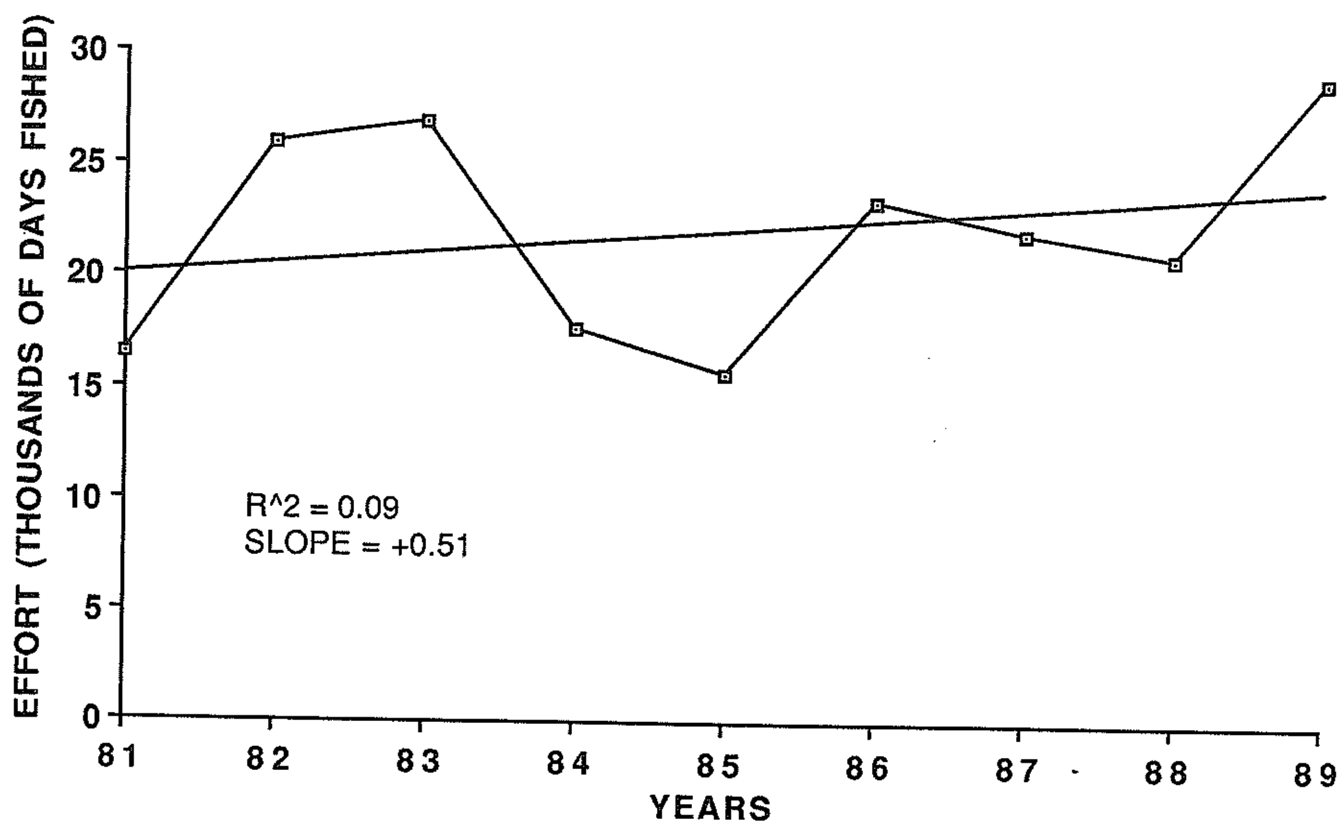


Figure 18. Effort in the offshore Atlantic shrimp fishery.

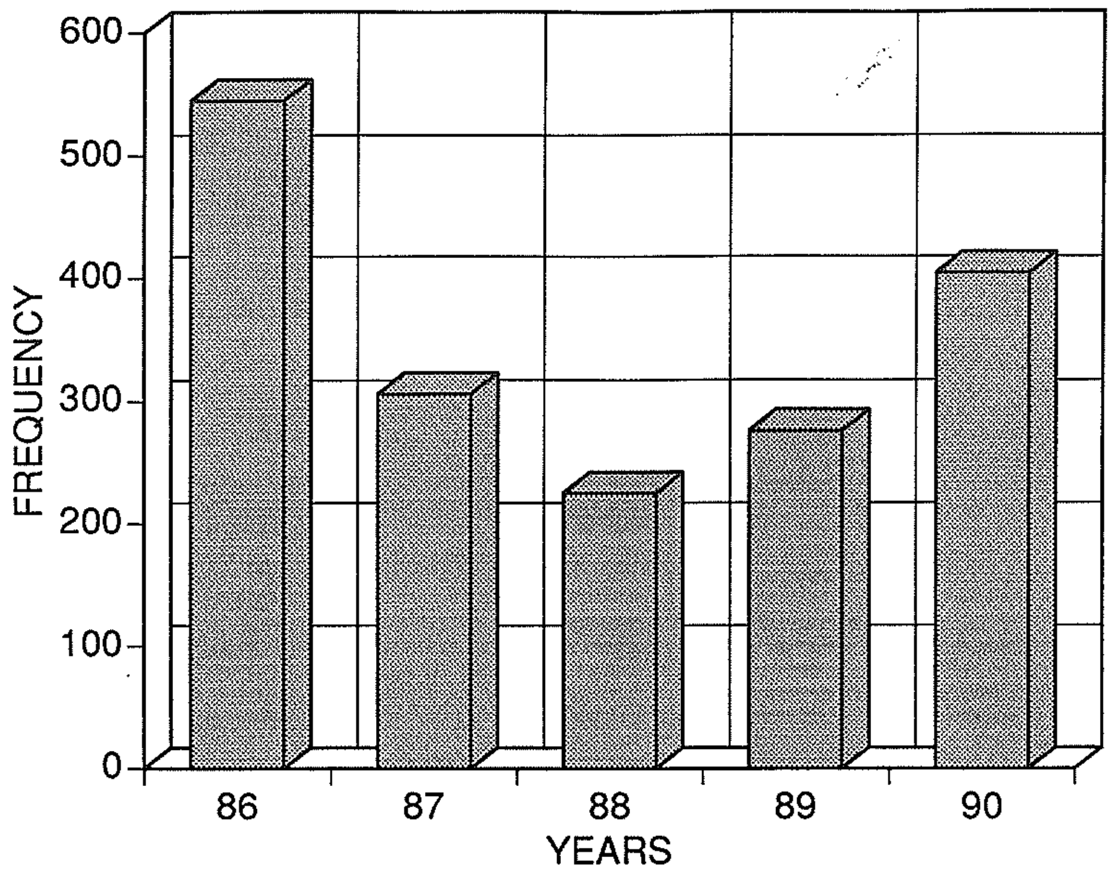


Figure 19. Turtle stranding frequency by year in statistical areas 17 - 21.

LIST OF APPENDICES

APPENDIX I

APPENDIX TABLES

Appendix I Table 1. Summary of operation codes for trawl performance.

A = Nets not spread; typically doors are flipped or doors hung together so net could not spread.
B = Gear bogged; the net has picked up a quantity of sand or mud such that the net can not be easily towed.
C = Bag choked; the catch in the net is prevented from getting into the bag by something (grass, sticks, turtle, etc.) clogging net or by the twisting of the lazy-line.
D = Gear not digging; the net is fishing off the bottom due to insufficient weight.
E = Twisted warp or line; the cables composing the bridle get twisted (from passing over blocks which occasionally must be removed before continuing to fish). Use this code if catch was affected.
F = Gear fouled; the gear has become entangled in itself. Typically this involves the webbing and some object like a float or chains.
G = Bag untied; bag of net not tied when dragging net.
H = Rough weather; if the weather is so bad fishing is stopped, then the previous tow should receive this code if the rough conditions affected the catch.
I = Torn webbing or lost net; usually results from hanging the net and tearing it loose. The net comes back with large tears if at all. Do not use this code if there are only a few broken meshes. Continue using this code until net is repaired or replaced.
J = Dumped catch; tow was made but catch was discarded, perhaps because of too much trash, fish, sponge. Give reason in Comments.
K = No pick up; tow made but net not dumped on deck because nets are brought up, boat changes location and nets are towed more before decking.
L = Hung up; untimely termination of a tow by a hang. Specify trawl(s) which were hung and caused lost time in Comments.
M = Bags dumped together and catches not separated.
N = Net did not fish; no apparent cause.
O = Gear fouled on object; typically a log caught in bag or TED. Net may be towed but performance is affected. Give specifics in Comments.
P = No measurement taken of shrimp or total catch.
Q = Cable breaks and net lost. Describe in Comments.
R = Net caught in wheel.
S = Tickler chain fouled or tangled.
T = Other Problems
U = TED's tied shut.
W = Defective TEDs (incorrect materials used by manufacturer).
Z = Successful tow

Appendix I Table 2. Results of multivariate paired t-test for data with try nets included. Comparisons between CPUE (lbs/hr) of standard and TED-equipped nets by tow[a].

	N TOWS	P Values: CPUE (lb/hr) shrimp	Mean CPUE (lb/hr) shrimp std. net	Mean CPUE (lb/hr) shrimp TED net	Difference (std-TED) between mean CPUEs (lb/hr): shrimp	Difference (std-TED) between mean CPUEs (lb/hr): shrimp %
Overall	425	0.99	9.91	9.90	0.02	(0)
TED type						
GA/F[b]	188	<0.01	7.53	7.27	0.25	(+3)[c]
SS/F[d]	237	0.63	11.80	11.98	-0.17	(-1)
Months						
Dec-Feb	58	0.20	6.33	6.17	0.16	(+3)
Mar-May	48	0.04	9.37	8.88	0.49	(+5)
Jun-Aug	187	0.31	12.37	12.72	-0.34	(-3)
Sep-Nov	132	0.03	8.19	7.91	0.29	(+3)
Areas						
1-8	17	0.91	13.92	13.73	0.19	(+1)
9-12	13	0.23	5.18	4.27	0.91	(+18)
13-17	133	<0.01	8.40	8.04	0.35	(+4)
18-21	10	0.98	3.10	3.19	-0.09	(-3)
30-32	65	0.20	6.87	6.72	0.15	(+2)
34-35	187	0.31	12.37	12.72	-0.34	(-3)

Appendix I Table 2 (cont).

Day/Night

Day	158	0.81	9.99	9.87	0.12	(+1)
Night	171	>0.99	9.19	9.19	0.00	(0)
Both	96	0.88	11.05	11.18	-0.13	(-1)

[a] Numbers with decimals are rounded to nearest 0.01.
[b] Georgia TED with funnel.
[c] Positive indicates higher catch in standard nets; negative indicates higher catch in TED nets.
[d] Super Shooter TED with funnel.

Appendix I Table 3. Frequency of operation codes for standard net, Georgia TED with a funnel, and Super Shooter TED with a funnel.

Operation Code	Standard Net Freq.	Standard Net %	Georgia TED w/funnel Freq.	Georgia TED w/funnel %	Super Shooter TED w/funnel Freq.	Super Shooter TED w/funnel %
B	16	1.2	1	0.2	1	0.2
BG	2	0.1	0	0.0	0	0.0
BI	1	0.1	0	0.0	0	0.0
BK	2	0.1	0	0.0	0	0.0
BM	3	0.2	0	0.0	0	0.0
C	0	0.0	0	0.0	1	0.2
CI	1	0.1	0	0.0	0	0.0
CO	0	0.0	0	0.0	3	0.5
D	0	0.0	1	0.2	0	0.0
DO	0	0.0	1	0.2	0	0.0
E	0	0.0	0	0.0	1	0.2
EM	1	0.1	0	0.0	0	0.0
F	2	0.1	6	1.3	4	0.7
FU	2	0.1	0	0.0	0	0.0
G*	2	0.1	1	0.2	0	0.0
GM*	1	0.1	0	0.0	0	0.0
I*	10	0.7	4	0.9	6	1.1
IM*	0	0.0	3	0.7	0	0.0
IO	0	0.0	0	0.0	1	0.2
IP*	2	0.1	0	0.0	0	0.0
IS	1	0.1	0	0.0	0	0.0
J*	16	1.2	2	0.4	10	1.8
K*	10	0.7	10	2.2	0	0.0
KB	4	0.3	0	0.0	0	0.0
KI*	1	0.1	0	0.0	0	0.0
KO	3	0.2	2	0.4	0	0.0
L*	2	0.1	3	0.7	1	0.2
LI*	1	0.1	2	0.4	0	0.0
LP*	4	0.3	0	0.0	0	0.0
M*	241	17.4	29	6.4	137	24.9
MB	2	0.1	0	0.0	0	0.0
MI*	1	0.1	0	0.0	4	0.7
ML*	2	0.1	0	0.0	2	0.4
MO	0	0.0	1	0.2	0	0.0
MP*	33	2.4	13	2.9	0	0.0
MS	7	0.5	0	0.0	4	0.7
MT	1	0.1	0	0.0	0	0.0
N	0	0.0	0	0.0	1	0.2
O	15	1.1	7	1.5	16	2.9
OB	1	0.1	0	0.0	0	0.0
OM	1	0.1	2	0.4	7	1.3
P*	53	3.8	24	5.3	5	0.9
Q*	2	0.1	0	0.0	0	0.0
S	23	1.7	9	2.0	9	1.6
SP	0	0.0	1	0.2	0	0.0
U*	6	0.4	0	0.0	0	0.0
Z*	907	65.6	334	73.2	337	61.3
Totals	1382		456		550	

* These operational codes reflect tows with no gear-related problems attributed to TEDs.

Appendix I Table 4. Frequency of operation codes for Georgia TED without a funnel, Morrison TED, and a NMFS-type TED.

Operation	Georgia TED without funnel		Morrison TED		NMFS-TYPE TED	
Code	Freq.	%	Freq.	%	Freq.	%
B	0	0.0	0	0.0	1	1.1
BR	0	0.0	0	0.0	1	1.0
C	1	0.2	2	2.9	0	0.0
F	0	0.0	1	1.5	1	1.1
I*	2	3.9	0	0.0	1	1.1
IB	0	0.0	0	0.0	0	0.0
IM*	2	3.9	0	0.0	0	0.0
K*	0	0.0	28	41.2	0	0.0
M*	16	31.4	9	13.2	1	1.1
MP	0	0.0	6	8.8	0	0.0
O	1	2.0	0	0.0	9	9.9
S	5	9.8	0	0.0	2	2.2
SO	1	2.0	0	0.0	0	0.0
U*	0	0.0	0	0.0	1	1.1
UI*	0	0.0	0	0.0	1	1.1
UO	0	0.0	0	0.0	2	2.2
Z*	23	45.1	22	32.5	1	78.1

* These operational codes reflect tows with no gear-related problems attributable to TEDs.

Appendix I Table 5. Frequency of operation codes for standard net, Super Shooter TED with funnel and Georgia TED with funnel.

Operation Code	Standard Net Freq.	Standard Net %	Super Shooter TED with funnel Freq.	Super Shooter TED with funnel %	Georgia TED with funnel Freq.	Georgia TED with funnel %
Group 1[a]	88	6.4	31	6.8	44	8.0
Group 2[b]	1294	93.6	425	93.2	506	92.0

[a] Group 1 = operation codes A, B, C, E, F, N, O, S, T plus multiple codes containing one of these letters. These codes reflect gear-related problems which may or may not be attributed to TEDs.

[b] Group 2 = operation codes G, I, J, K, L, M, P, Q, U, Z, plus multiple codes containing only these letters. These codes reflect tows with no gear-related problems attributable to TEDs.

Appendix I Table 6. Summary of regression analyses: TED-equipped vs standard shrimp nets by tedtype, area and season; data paired by tow.

Class	Dependent Variable	Independ. Variable	Sample Size	Slope	Intercept	Variance From Regression	R^2	Regression Equation
GT/WF	TEDCPUSH	STDCPUSH	188	0.968[a]	0.269	1.734	0.888	Y = 0.269 + 0.968X
GT/WF	TEDSH	STDSH	188	0.945	1.690	34.320	0.900	Y = 1.690 + 0.945X
GT/WF	TEDCPUTR	STDCPUTR	188	0.964[a]	0.013	1.106	0.937	Y = 0.013 + 0.964X
GT/WF	TEDSHTR	STDSHTR	188	0.907	1.637	25.205	0.934	Y = 1.637 + 0.907X
GT/WF	TEDFI	STDFI	188	0.779	63.024	113671.468	0.603	Y = 63.024 + 0.779X
SH/WF	TEDCPUSH	STDCPUSH	236	0.947	0.438	5.363	0.951	Y = 0.438 + 0.947X
SH/WF	TEDSH	STDSH	236	0.942	1.141	25.596	0.945	Y = 1.141 + 0.942X
SH/WF	TEDCPUTR	STDCPUTR	236	0.991[a]	0.279	7.843	0.938	Y = 0.279 + 0.991X
SH/WF	TEDSHTR	STDSHTR	236	0.952	1.303	33.091	0.936	Y = 1.303 + 0.952X
SH/WF	TEDFI	STDFI	236	0.802	81.706	235348.018	0.557	Y = 81.706 + 0.802X
TEXAS	TEDCPUSH	STDCPUSH	10	1.168[a]	-0.670	0.181	0.882	Y = -0.670 + 0.168X
TEXAS	TEDSH	STDSH	10	1.196[a]	-4.226	5.237	0.878	Y = -4.226 + 1.196X
TEXAS	TEDCPUTR	STDCPUTR	10	1.208[a]	-0.551	0.193	0.823	Y = -0.551 + 1.208X
TEXAS	TEDSHTR	STDSHTR	10	1.227[a]	-3.409	5.778	0.873	Y = -3.409 + 1.227X
TEXAS	TEDFI	STDFI	10	0.523[a]	67.485	5358.663	0.353	Y = 67.485 + 0.523X
LA	TEDCPUSH	STDCPUSH	133	1.001[a]	-0.006	2.376	0.911	Y = 0.006 + 1.001X
LA	TEDSH	STDSH	133	0.958[a]	1.388	48.762	0.890	Y = 1.388 + 0.958X
LA	TEDCPUTR	STDCPUTR	133	0.968[a]	-0.085	1.304	0.955	Y = -0.085 + 0.968X
LA	TEDSHTR	STDSHTR	133	0.936	0.584	30.676	0.937	Y = 0.584 + 0.936X
LA	TEDFI	STDFI	133	0.720	120.842	151246.680	0.522	Y = 120.842 + 0.720X
MS/AL/PAN	TEDCPUSH	STDCPUSH	13	0.981[a]	0.235	0.052	0.997	Y = 0.235 + 0.981X
MS/AL/PAN	TEDSH	STDSH	13	0.984[a]	1.243	1.690	0.977	Y = 1.243 + 0.984X
MS/AL/PAN	TEDCPUTR	STDCPUTR	13	0.713	0.570	0.041	0.998	Y = 0.570 + 0.713X
MS/AL/PAN	TEDSHTR	STDSHTR	13	0.715	3.137	1.367	0.998	Y = 3.137 + 0.715X
MS/AL/PAN	TEDFI	STDFI	13	1.340	-88.135	26006.966	0.920	Y = -88.135 + 1.340X
WFL	TEDCPUSH	STDCPUSH	17	0.896[a]	0.233	1.777	0.837	Y = 0.233 + 0.896X
WFL	TEDSH	STDSH	17	0.942[a]	-1.472	22.368	0.905	Y = -1.472 + 0.942X
WFL	TEDCPUTR	STDCPUTR	17	0.909[a]	1.085	2.812	0.769	Y = 1.805 + 0.909X
WFL	TEDSHTR	STDSHTR	17	0.995[a]	-0.329	36.540	0.866	Y = -0.329 + 0.995X
WFL	TEDFI	STDFI	17	0.935[a]	2.829	1251.028	0.480	Y = 2.829 + 0.935X
FL/NC	TEDCPUSH	STDCPUSH	251	0.944	0.558	4.861	0.951	Y = 0.588 + 0.944X
FL/NC	TEDSH	STDSH	251	0.938	1.436	21.635	0.937	Y = 1.436 + 0.938X
FL/NC	TEDCPUTR	STDCPUTR	251	0.997[a]	0.248	7.113	0.939	Y = 0.248 + 0.997X
FL/NC	TEDSHTR	STDSHTR	251	0.963	1.077	27.419	0.928	Y = 1.077 + 0.963X
FL/NC	TEDFI	STDFI	251	0.810	65.765	221287.918	0.569	Y = 65.765 + 0.810X
WINTER	TEDCPUSH	STDCPUSH	58	0.972[a]	0.543	0.554	0.966	Y = 0.543 + 0.972X
WINTER	TEDSH	STDSH	58	0.995[a]	1.888	9.891	0.958	Y = 1.888 + 0.995X
WINTER	TEDCPUTR	STDCPUTR	58	0.983[a]	-0.055	0.455	0.973	Y = -0.055 + 0.983X
WINTER	TEDSHTR	STDSHTR	58	0.967[a]	-0.061	6.218	0.976	Y = -0.061 + 0.967X
WINTER	TEDFI	STDFI	58	0.622	91.929	19665.625	0.542	Y = 91.929 + 0.622X
SPRING	TEDCPUSH	STDCPUSH	48	0.981[a]	0.040	1.682	0.963	Y = 0.040 + 0.981X
SPRING	TEDSH	STDSH	48	0.956[a]	0.918	19.995	0.959	Y = 0.918 + 0.956X
SPRING	TEDCPUTR	STCCPUTR	48	0.943	0.045	1.507	0.969	Y = 0.045 + 0.943X
SPRING	TEDSHTR	STDSHTR	48	0.932	0.354	21.888	0.959	Y = 0.354 + 0.932X
SPRING	TEDFI	STDFI	48	0.820	39.304	8595.137	0.734	Y = 39.304 + 0.820X

Appendix I Table 6 (cont).

Class	Dependent Variable	Independ. Variable	Sample Size	Slope	Intercept	Variance From Regression	R^2	Regression Equation
SUMMER	TEDCPUSH	STDCPUSH	186	0.944	0.514	6.377	0.949	Y = 0.514 + 0.944X
SUMMER	TEDSH	STDSH	186	0.937	1.196	27.457	0.937	Y = 1.196 + 0.937X
SUMMER	TEDCPUTR	STDCPUTR	186	0.992[a]	0.443	9.406	0.935	Y = 0.443 + 0.992X
SUMMER	TEDSHTR	STDSHTR	186	0.962[a]	1.421	35.394	0.927	Y = 1.421 + 0.962X
SUMMER	TEDFI	STDFI	186	0.793	98.705	296552.568	0.529	Y = 98.705 + 0.793X
FALL	TEDCPUSH	STDCPUSH	132	0.978[a]	0.058	2.191	0.864	Y = 0.058 + 0.978X
FALL	TEDSH	STDSH	132	0.946[a]	1.034	43.398	0.891	Y = 1.034 + 0.946X
FALL	TEDCPUTR	STDCPUTR	132	0.964[a]	0.008	1.401	0.924	Y = 0.008 + 0.964X
FALL	TEDSHTR	STDSHTR	132	0.900	2.024	33.784	0.924	Y = 2.024 + 0.900X
FALL	TEDFI	STDFI	132	0.784	67.685	153299.221	0.587	Y = 67.685 + 0.784X

a = Slopes not significantly different from 1.
GT/WF = GEORGIA TED WITH A FUNNEL
SH/WF = SUPER SHOOTER TED WITH A FUNNEL
TEDCPUSH = CPUE OF SHRIMP IN TED NET NOT ADJUSTED FOR TRY NET
STDCPUSH = CPUE OF SHRIMP IN STANDARD NET NOT ADJUSTED FOR TRY NET
TEDSH = CATCH OF SHRIMP IN TED NET NOT ADJUSTED FOR TRY NET
STDSH = CATCH OF SHRIMP IN STANDARD NET NOT ADJUSTED FOR TRY NET
TEDCPUTR = CPUE OF SHRIMP IN TED NET ADJUSTED FOR TRY NET
STDCPUTR = CPUE OF SHRIMP IN STANDARD NET ADJUSTED FOR TRY NET
TEDSHTR = CATCH OF SHRIMP IN TED NET ADJUSTED FOR TRY NET
STDSHTR = CATCH OF SHRIMP IN STANDARD NET ADJUSTED FOR TRY NET
TEDFI = CATCH OF FISH IN TED NET NOT ADJUSTED FOR TRY NET
STDFI = CATCH OF FISH IN STANDARD NET NOT ADJUSTED FOR TRY NET

[a] These slopes <u>are not</u> significantly different from 1.

Appendix I Table 7. Frequency of paired tows by area and season for the Georgia TED without a funnel (N=15), Morrison TED (N=13) and a NMFS-Type TED (N=76).

Georgia TED

	LA	TX	SC
Winter	--	--	--
Spring	--	--	--
Summer	--	--	--
Fall	--	15	--

Morrison TED

	LA	TX	SC
Winter	--	--	9
Spring	--	--	--
Summer	--	--	3
Fall	--	--	1

NMFS-Type TED

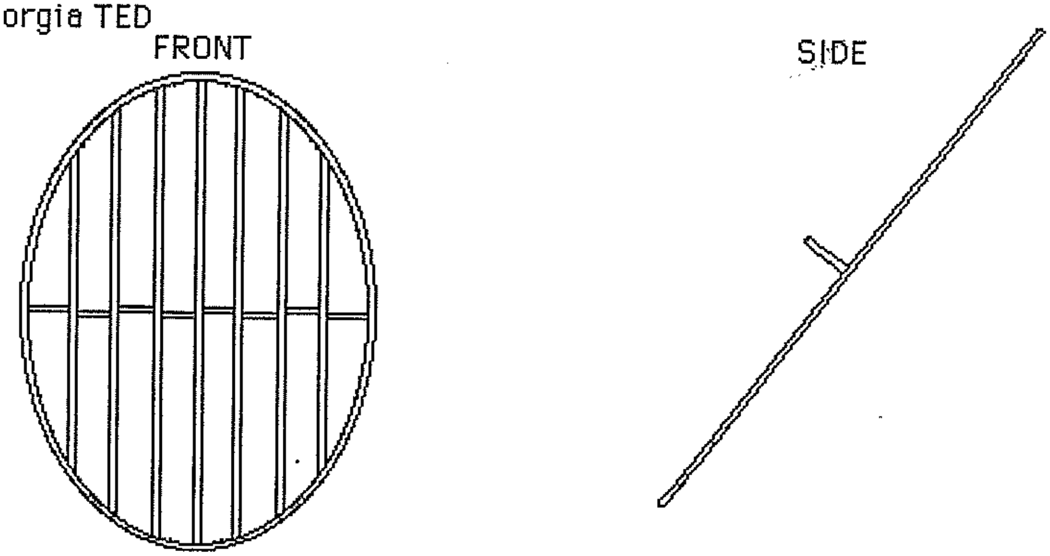
	LA	TX	SC
Winter	--	--	--
Spring	54	--	--
Summer	22	--	--
Fall	--	--	--

APPENDIX II

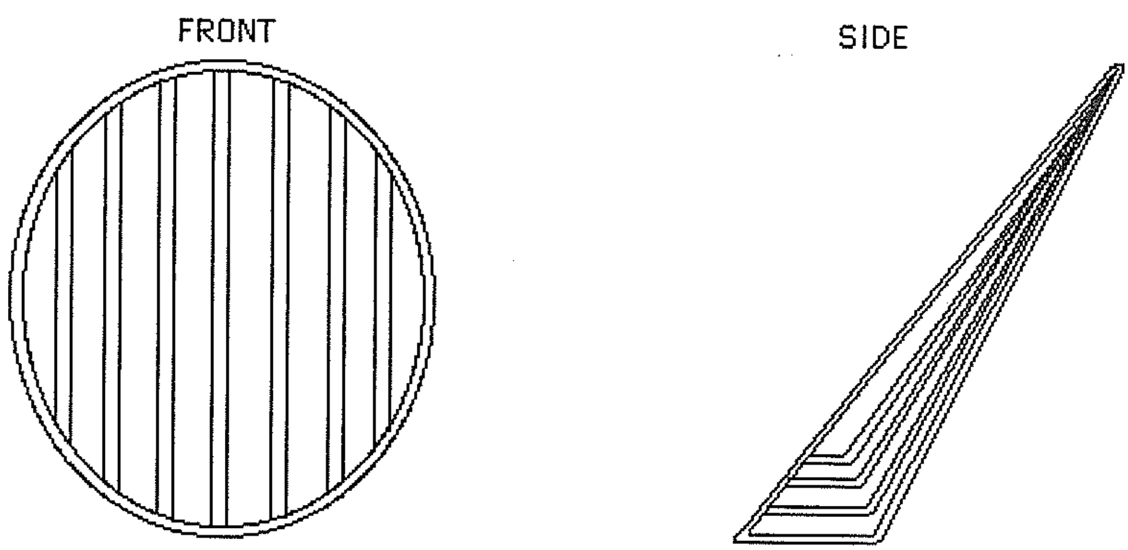
APPENDIX FIGURES

Appendix II Figure 1. Schematics of Georgia and Super Shooter TEDs and accelerator funnel.

A. Georgia TED



B. Super Shooter TED



C. TED with accelerator funnel installed in shrimp trawl